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Macroprocesses and Adaptive Instruction

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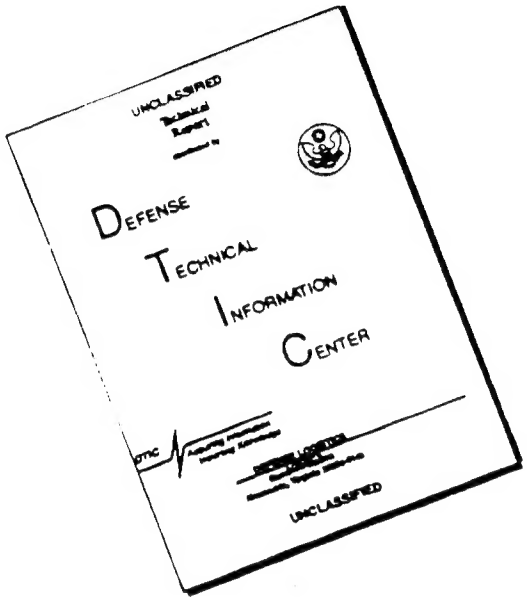

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A paradigm for the unobtrusive monitoring of students' cognitive processing of instruction (macroprocessing) by microcomputer was developed for this project. The paradigm was used in four experiments that examined the types of processing students use during their reading of expository texts. The results indicated that students' voluntary use of macroprocesses and review was highly variable and ineffective. However, when the instructional system prescribed or prompted use of review if there was evidence of poor comprehension, or when an explanation of the value of review was provided, learning generally improved, especially for students with limited prior knowledge of the content. The implications of these results for further research are discussed. The findings also suggest that the paradigm can be used to deliver cost-effective instruction to improve students' cognitive processing of reading and ultimately their comprehension. This project solved some of the programming, procedural, and technical problems encountered in developing a computer-based delivery system for such instruction.

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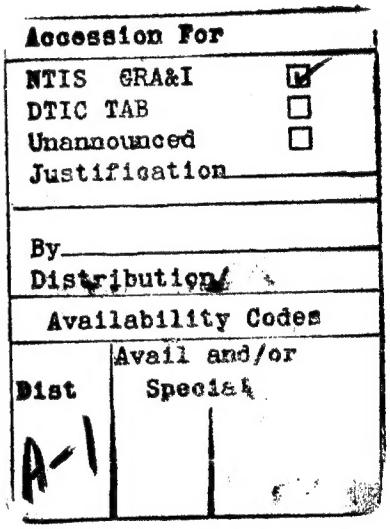

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MACROPROCESSES AND ADAPTIVE INSTRUCTION

CONTENTS

Chapter I. Macroprocesses and Adaptive Instruction: Final Report

Sigmund Tobias

Abstract

A paradigm for the unobtrusive monitoring of students' cognitive processing of instruction (macroprocessing) by microcomputer was developed for this project. The paradigm was used in four experiments which examined the types of processing students use during their reading of expository texts. The results indicated that students' voluntary use of macroprocesses and review was highly variable and ineffective. However, when the instructional system prescribed or prompted use of review if there was evidence of poor comprehension, or when an explanation of the value of review was provided, learning generally improved, especially for students with limited prior knowledge of the content. The implications of these results for further research are discussed. The findings also suggest that the paradigm can be used for the delivery of cost-effective instruction to improve students' cognitive processing of reading, and ultimately their comprehension. This project solved some of the programming, procedural, and technical problems encountered in developing a computer-based delivery system for such instruction. Since professionally trained instructors are not required by the system, an efficient model for the delivery of instruction in such processes as review, preview, highlighting and others can easily be developed.

The basic purposes of this research program were to study whether different instructional methods called for different types or intensities of cognitive processing of instruction, called macroprocesses. Macroprocesses (Tobias, 1982) were conceptualized as relatively molar cognitive activities performed by students while learning from instruction such as, reviewing, taking notes, consulting easier explanations and similar activities. A further purpose was to determine whether macroprocesses were differentially available to students of different characteristics. Finally, this project examined whether there were reliable interactions between the macroprocesses demanded by the methods and available to students.

Background

This project was stimulated by research on the interaction of student characteristics and instructional methods, especially as they relate to problems in studying student cognitive processing of instruction. An overview of this research, of the experimental paradigm developed for this project, and general descriptions of the four experiments conducted appears below. Comprehensive reviews of the pertinent literature, as well as detailed descriptions of each of the experiments and their findings appear in each of the succeeding chapters describing the experiments.

ATI Research

A large number of investigations have studied the interaction between student aptitudes, or more generally individual difference variables, and instructional methods or treatments. This work has come to be known as aptitude treatment interaction research, commonly

abbreviated as ATI (Cronbach & Snow, 1977). Consistent, replicated ATIs are expected to provide the knowledge base for a truly individualized instruction. That is, assigning students to different instructional methods in order to optimize their learning implies the existence of a knowledge base consisting of verified ATIs, i.e., interactions between student characteristics and instructional methods. Unfortunately, analyses of this research indicate that there are few such replicated ATIs (Cronbach & Snow, 1977; Tobias, 1981; Snow & Lohman, 1984).

Cronbach and Snow (1977) concluded their massive review of the ATI literature by indicating that "no aptitude by treatment interactions are so well confirmed that they can be used directly as guides to instruction" (p. 492). They suggested that there was some evidence for several patterns of interactions which deserved further investigation. These included findings that students high in general ability tended to succeed with instructional treatments offering little assistance, whereas those lower in such abilities profited from the addition of various forms of assistance, such as advance organizers, demonstrations, and the like. In the personality area, Cronbach and Snow found that interactions appeared with some frequency and concluded that "students with constructive motivation tended to benefit from treatment conditions that provided more freedom and more challenge, i.e., treatments that look to the learner himself to apply a good deal of the structure and the specification of the task" (p. 469). The opposite may be expected for those whose motivation was less strongly constructive. Constructive motivation was defined by high scores on scales measuring a preference to achieve independently and low scores on measures of anxiety,

defensiveness or similar characteristics.

An analysis of the ATI evidence (Tobias, 1982) suggested some reasons for the frequently inconsistent findings. First, the alternate instructional methods used in ATI research were assumed to require different macroprocesses. But methods which appear externally different from one another may not call for different macroprocesses. Unfortunately, most ATI studies provide little evidence that the instructional methods employed in fact required different macroprocessing. Second, ATI research assumes that the macroprocesses required by the instructional methods are differentially available to students of varying characteristics. Again, ATI studies provide little independent evidence of such differential availability. Therefore, the failure to find consistent ATIs could be traced to these unverified assumptions. Research on the macroprocesses used by students of varying characteristics and those required by different instructional methods is needed in order to generate replicable ATIs.

Problems In Studying Macroprocesses

The study of macroprocesses employed by students presents a number of problems. Garner (1984) indicated that differences in cognitive processing could be investigated by obtaining introspective evidence from self-reports of students' cognitive activities while learning. She suggested that there are problems with this type of evidence, as well as the possible interpretations to be made from it. These problems included potential errors with the accuracy and clarity of self-reports attributable to differences in students' verbal ability. Garner also suggested that there was a tendency for students to report strategies they believed they should have used,

rather than those actually employed. In view of these problems, the first objective of this project was to develop an unobtrusive research paradigm to monitor students' cognitive processing of instruction which would not be subject to the problems associated with students' self-reports.

Experimental Paradigm

The paradigm developed used students' reading of meaningful expository text displayed on microcomputers as the major instructional activity. Different instructional methods were implemented by varying the presence or absence of adjunct questions, and/or the conditions under which students reviewed their reading. A substantial body of research (Anderson and Biddle, 1975; Rickards, 1979; Hamilton, 1985) has found consistent differences between students exposed to adjunct questions after reading text, and those not receiving such assistance. It was reasoned, that different macroprocesses would have to be employed by students in various conditions in order to lead to alterations in learning outcomes. Indices of macroprocessing were obtained by making a variety of processing options available to students while they read passages displayed on microcomputers which were programmed to retain data on option use.

In a pilot study students were questioned about the strategies customarily employed while reading expository text for school. A set of macroprocesses, similar to the strategies most frequently reported in the pilot study, were made conveniently available to students as options in each of the experiments in this project. Students' use of these options defined their macroprocessing.

Adjunct questions requiring fill-in answers were constructed

for every screenful of two or three paragraphs. The questions dealt with facts, concepts, and the application of these concepts. In some experimental conditions, the correctness of the responses to the adjunct questions was evaluated by microcomputer by scanning a set of possible correct answers and their synonyms, or phrases denoting the same concept. The answer set was intended to determine students' understanding of the passage's meaning, hence spelling errors in the answers were tolerated.

In addition to manipulating presence or absence of questions, and types of review, a second set of independent variables in this project were the effects of differences in student characteristics on outcomes and on use of macroprocesses. Two variables which had been consistently useful in ATI research were selected: Student variation in prior knowledge of the content and test anxiety. In previous research (Tobias, 1976; 1981) differences in prior knowledge had been found to interact consistently with instructional methods. A considerable body of research has also related test anxiety to learning from meaningful instruction (Sarason, 1980), and clearly specified theoretical relationships between test anxiety and instructional variables (Tobias, 1979; 1980; 1985) have been developed. Student differences on these variables were assessed in all project experiments, and their interactions with different instructional methods studied.

Awareness of Macroprocesses. Another issue investigated in several of these experiments was students' awareness of the macroprocesses used. That is, do students have an accurate picture of the types of cognitive activities they engage in while learning from reading? It was felt that data about students' knowledge of

their cognitive processing activities would be an important consideration in developing instructional interventions designed to teach effective macroprocesses for use in reading. Thus, several of the experiments investigated the relationships between the macroprocessing options students actually employed during reading, as indicated by the data collected on computers, and their self-reports of these activities.

Instructional Text and Options. A text was developed dealing with some fundamental concepts of data processing and computer programming. Examples of these concepts were supplied by describing some instructions from the BASIC computer language. The same text was used in all four investigations.

Two versions of the text were created. The main text was written in a fourteenth grade vocabulary (Frye, 1968), and consisted of 172 sentences. An alternate, easier passage consisted of 182 sentences using tenth grade vocabulary. Every paragraph of the alternate text was identical to the comparable paragraph of the main passage. The alternate passage was structured so that superordinate sentences were regularly followed by subordinate sentences. Students could consult the alternate text after completing a comparable paragraph in the main text, signalled by a beep from the computer's buzzer. All text was presented in numbered sentences, one at a time. When students touched the space bar the preceding sentence was erased, though its number and the space it occupied remained on the screen while the succeeding material appeared.

The following macroprocessing options were available to students: 1) They could consult the alternate, easier text. 2) They could review the main text in two ways: (a) Whenever the

backward arrow was touched the preceding sentence was displayed. (b) Students could also request review of a range of sentences by typing the numbers of those they wished to re-read (i.e., sentences 70-73). 3) The alternate text could be reviewed in the same manner as the main text. 4) Notes could be taken on the computer screen and 5) the notes could be reviewed whenever the students wished. 6) Students could inspect a menu describing each of the options and how they were invoked. In the first study three additional options were used: 1) Students could also preview the main or 2) alternate texts and 3) consult an organizational display describing the text headings and subheadings, as well as the sentence numbers in each section.

Pre- and Posttest. A posttest requiring fill-in responses was administered in a paper and pencil format after students finished reading the text. This posttest was divided into two subtests: a) A relevant posttest containing 26 items related to the content of the adjunct questions. b) An incidental subtest of 25 items dealing with materials not covered by the adjunct questions. Prior to working with the materials students also received a 50 item multiple-choice pretest to determine their prior knowledge of the subject matter.

Experiment I

The first experiment had several purposes. First, to develop and validate the instructional paradigm. Second, to obtain evidence on the frequency with which students used a variety of study options. Since prior research was based largely on students' self-reports of their study strategies, we hoped to determine actual use of macroprocesses in an unobtrusive manner while students were involved in learning. Third, preliminary evidence was sought as to whether various instructional methods required different utilization of these

strategies. Fourth, the relationship of differences in student characteristics to variation in the use of macroprocesses was studied. Finally, the interaction between instructional methods and student characteristics was also investigated.

Different instructional methods were implemented by varying text presentation modes. Specifically, one group read the passage with adjunct questions and received feedback about the correctness of their answers. A second group received adjunct questions without feedback, and a third group read the text without adjunct questions.

Results. The results of the first experiment replicated prior findings that students responding to adjunct questions learned more than those merely reading the text. The results indicated that the paradigm of displaying text on computers one sentence at a time resulted in findings comparable to those obtained when students read materials in more conventional modes. These findings suggested that the paradigm employed did not de-realize the reading task, and that results from this paradigm had applicability to more conventional reading of instructional text.

The macroprocessing results were surprising. There was incredible variability in students' use of macroprocessing options. The percentage of students who did not use an option at all varied from 18 to 88%. Option use was highly skewed; despite generally low use, a number of students utilized options very frequently. The standard deviations of option use data were often three times higher than the mean! Also, option use was generally unrelated to student characteristics or posttest, suggesting that the use of macroprocesses did not appear to improve learning. Finally, a number of significant interactions among methods, pretest and test anxiety

on macroprocesses were also found. In general, these indicated that as both prior knowledge and test anxiety increased, utilization of macroprocesses went up as well.

One interpretation of the extreme variability of the macroprocessing data could be that students regarded the macroprocessing options much the way they might a computer game. The fact that the grand mean of the total posttest score was 70% on a difficult fill-in examination suggested that this was an unlikely interpretation. Moreover, there was evidence suggesting that while none of the macroprocessing options singly contributed significantly to posttest score, the groups using all of the macroprocessing options more frequently did learn more than those using them less often.

Experiment II.

The findings of relatively unstrategic use of macroprocesses were followed up in this experiment. It was reasoned that if students were unable to use options to improve their comprehension, then perhaps the paradigm could be used to prescribe more effective use of macroprocessing options. That is, when students answered adjunct questions incorrectly it seemed reasonable to assume that: (a) They were having difficulties comprehending the text, and (b) such difficulty might be an optimal time for students to review their prior reading. The purpose of the second study, then, was to determine whether prescribed review when students' answers to adjunct questions were incorrect led to superior achievement compared to conditions in which students could review text whenever they wished.

Four groups were used in this experiment. Two of these were similar to the first experiment, i.e., one group read the text with,

and another group without adjunct questions. Two other groups were required to review when their answers to adjunct questions were incorrect. One of these had to review the preceding screen of main text, and the other the alternate text whenever their answers to adjunct questions were incorrect.

Results. The results indicated that the mandatory review groups learned more of the material related to the adjunct questions than the others. Furthermore, analysis of the review data indicated that compulsory reviews, i.e, reviews when answers to adjunct questions were incorrect, contributed significantly (60 and 54% of the variance) to posttest scores, whereas, voluntary reviews were not associated with outcome. This evidence, together with the data from the preceding study indicated that when left to their own devices students do not use macroprocesses effectively to improve learning. However, when they are prompted to do so macroprocesses are used much more effectively.

A number of significant interactions were also found. Some of these indicated that more knowledgeable students tended to use some of the macroprocessing options more frequently than those with little prior familiarity with the content. Particularly interesting was one interaction which indicated that knowledgeable students developed a preventive strategy so that they would not be required to review. That interaction (see Figure 3 in Chapter 3, page 3-29) suggested that knowledgeable students in the mandatory review groups consulted the alternate, easier passage more frequently than those less knowledgeable, presumably in order to learn the right answer to the adjunct questions and avoid being required to review.

Finally, the second experiment found little relationship between

students' self-reports regarding use of strategies in conventional reading, and the macroprocesses used in this experiment. It seemed possible that these results may have been attributed to the fact that students were unaccustomed to reading text displayed on a microcomputer one sentence at a time. These findings were followed up in the next experiment.

Discussion. The results suggested an interesting paradox regarding the use of macroprocesses. Some of the data from the first two experiments indicated variable and relatively ineffective use of macroprocesses. On the other hand, the interaction which indicated that students developed a strategy to avoid being required to review and other data gave evidence of relatively strategic reading. These results suggested that the variability in the effective use of macroprocesses may be attributed to ambiguity regarding the meaning of comprehension to students. That is, the representation of knowledge in novel areas may be relatively undifferentiated and students may have some difficulty knowing when they comprehend the material. Further research in which the assistance given to students to assess their comprehension was varied seemed indicated in order to examine these questions.

Experiment III

This experiment investigated whether providing students with criteria against which to assess their comprehension leads to more effective use of macroprocesses. Students were randomly assigned to either an optional or a required review group; review was required when students' answers to adjunct questions were incorrect. Within these classifications students were randomly assigned to one of three groups: One receiving adjunct questions, and two groups in which

additional support for review was provided. In one group, students were instructed to think of the preceding question as they conducted either voluntary or required reviews; in another group the failed adjunct question was exposed at the bottom of the screen while students conducted their reviews. The study conformed to a 2 (required and optional review) X 3 (support for review) factorial design and also included measures of prior knowledge and test anxiety.

In this study review was linked with improved comprehension by suggesting (in the optional review group), or requiring (in the mandatory review) that students review in order to correct their wrong answer to the adjunct question. Such prompting had not occurred in prior investigations.

Results. Surprisingly, there were no significant differences between optional or required review, nor were there any differences among the three review modes in either posttest scores or use of macroprocesses.

The adjunct question-optional review group in this experiment was directly comparable to similar groups in the two preceding studies. A comparison of the use of reviews in the first three experiments, shown in Table 1, indicates that the optional review

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Insert Table 1 about here

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groups in this experiment re-read more sentences than in either of the preceding studies, presumably accounting for the absence of differences between optional and required review groups. In addition to reviewing more frequently, the results suggested that prompting students to re-read by relating reviews to correction of answers

enabled students to review more effectively to improve their comprehension.

There were also a number of significant disordinal interactions involving test anxiety, choice, and presentation modes. In general, the interactions suggested that optional review was optimal for students below the mean in test anxiety, whereas the learning of students in these conditions declined as test anxiety scores increased. On the other hand, students above the mean in test anxiety performed best when they were required to review; as test anxiety decreased, performance of students in the required review condition declined as well. These interactions confirmed expectations (Tobias, 1985) that both the cognitive representation of high anxiety and anxiety related preoccupations reduce the proportion of cognitive capacity anxious students are able to devote to a task. By reducing the demands on memory, mandatory review may lower the cognitive capacity needed to work on the task, hence, enabling anxious students to function effectively despite their anxiety. For less anxious students, on the other hand, mandatory reviews may force them to engage in unnecessary activities; such students appear to function optimally when the choice of whether to review is left to their own decision.

In the mandatory review groups, the number of sentences students were required to re-read, because their answer to the adjunct questions had been incorrect, contributed substantial and significant variance to posttest scores. On the other hand, sentences reviewed voluntarily by students in mandatory review groups were not associated with posttest. In optional review groups, the number of sentences students re-read after giving incorrect answers to adjunct

questions were significantly associated with posttest. Sentences re-read by the optional review groups at all other times were not significantly associated with outcomes.

Students were questioned both about their use of reading strategies in general, as well as their use of macroprocesses during the experiment. In general, the results indicated that neither questionaire was significantly associated with actual option use during the study. The median relationship between reported and actual use for the total sample accounted for less than one percent of the variance, and over half of the correlations were not significant. The results of both this and the preceding study suggest that students are not aware of the strategies they use.

Experiment IV

In view of the apparent effectiveness of prompting students to review more frequently and more effectively, this experiment investigated whether explicit instruction about the importance of review would improve learning, especially for students with limited prior knowledge of the subject matter. The experiment consisted of two groups, one receiving an explanation of the value of review and a second group for whom that explanation was omitted. Within these classifications students were randomly assigned to read the passage in one of three presentation modes: Without adjunct questions, with adjunct questions, and adjunct questions plus required review if students' answers to adjunct questions were wrong.

Results. The results indicated that explanations of the value of review did not improve learning for all students. But, a significant interaction between providing explanations and pretest, on both relevant and incidental posttest, indicated that explanations

improved the performance of students at or below the average in prior knowledge while they interfered somewhat with the learning of students with substantial prior familiarity. These interactions are shown in Figures 5.1 and 5.2 on pages 5-29 and 5-30.

These findings are similar to others summarized by Snow and Lohman (1984) indicating that instruction in the use of cognitive strategies often benefits students lacking such learning tools and interferes with the performance of students who have their own, more effective instructional strategies. The present results extend these findings to instruction in the use of review and suggest that such instruction may be valuable for students to whom the material to be learned is novel.

For the mandatory review groups, the number of sentences students were required to review contributed significantly to posttest score, whereas voluntary reviews were not associated with outcome. The total number of sentences re-read by the optional review groups after incorrect answers to adjunct questions was significantly associated with posttest scores. Sentences reviewed at all other times did not contribute to outcome.

General Discussion

The results from this project will be discussed in terms of their implications for the following issues: The research paradigm developed for this project, the effectiveness of voluntary reviews compared to mandatory or prompted re-reading, students' awareness of strategy use, ATI research, and implications for training students to improve their comprehension.

Utility of Experimental Paradigm

The results of the four experiments summarized above were

encouraging with respect to the utility of the paradigm used to monitor cognitive processing of instruction unobtrusively. One concern in developing a new research paradigm is whether the findings generated apply to more conventional situations, or whether the paradigm in some way derealizes the task. One way of determining the utility and generalizability of the paradigm is to examine whether results obtained from it replicate those found in more conventional situations.

Project results regarding the effects of adjunct questions were similar to those generally reported in this literature (Anderson & Biddle, 1975; Hamilton, 1985). The majority of the studies found adjunct questions to have a facilitating effect on posttest items relevant to the questions, and a minority reported facilitation on both incidental and relevant posttests. In this project students receiving adjunct questions learned more of the material related to the questions than those merely reading the text. In the first experiment the adjunct question group outperformed the others on both the relevant and incidental subtests, whereas in the later studies groups receiving adjunct questions outperformed the others only on posttest items related to the questions. Even though, no study compared students' reading on computers and in other text formats, the similarity of project findings to those in the adjunct question literature suggests that students' reading during the experiments was comparable to more typical text-like reading situations. This paradigm can, therefore, be used profitably when unobtrusive monitoring of students' cognitive processing of instruction is required for research and/or training efforts.

Voluntary and Prescribed Reviews

Another consistent finding in the studies was that students typically did not use macroprocesses in general, and review in particular, very efficiently to improve comprehension. The results indicated that the variability of macroprocessing use data was relatively high, and utilization of review or other macroprocesses had either weak associations with posttest scores or was not related to outcomes at all. Experiments II through IV permitted a comparison of students' voluntary use of review, one of the available macroprocesses, and prescribed review when there was evidence of comprehension difficulty, i.e., when answers to adjunct questions were incorrect. In every one of these comparisons, forced reviews contributed substantial variance (in the area of 45%-60%) to posttest scores, whereas, voluntary reviews were not significantly associated with outcome in any study.

Several of the studies also permitted comparisons between prompted reviews, that is, reviews when students were asked whether they wished to re-read in order to correct their answers to the preceding adjunct questions, and reviews conducted at all other times. In these cases as well, prompted reviews were significantly associated with posttest scores (though, these effects were smaller than those for required review), whereas all other reviews did not contribute to posttest. These data indicate that without external intervention students do not use reviews very effectively. However, the effectiveness of review improves if it is prescribed or prompted when there are signs of comprehension difficulty.

In general, the total number of reviews were negatively correlated with both pretest and posttest for groups that were either forced or prompted to review. The negative correlations do <u>not</u>

indicate that the lower scores were a function of the number of reviews. Instead, the negative relationships occurred because students with the lowest pretest tended to obtain the lowest posttest scores; they were also forced to review more frequently than more knowledgeable students, because they gave more wrong answers to adjunct questions than those scoring higher on the pretest. Since required review groups re-read more and generally also learned more than those merely reading the passage without questions and, in some experiments, than those for whom review was optional, these findings suggest that less knowledgeable students would have learned even less if they had not been required to review. When the total number of reviews was separated into forced and voluntary categories, correlations between voluntary reviews and posttest were no longer significant, though forced reviews continued to be significantly and negatively related to posttest score. Clearly then, the negative correlation between total reviews and posttest were a function of the experimental arrangements.

The importance of external prompting of macroprocessing is also supported by other evidence from this project. As indicated above, in Experiments III and IV, students were prompted to review if they wished to correct wrong answers to adjunct questions. Such prompting apparently increased the number of reviews and reduced learning differences between optional and required review groups. Perhaps the major reason that both requiring and prompting review increased the amount of re-reading is that students, especially those for whom the subject was novel, often do not know when their comprehension is faulty. That is, students with limited prior knowledge of a subject may have an undifferentiated internal representation of the content.

While reading, they probably do not know whether they have mastered the subject matter satisfactorily. Providing such students with adjunct questions, and prompting or requiring review gives them more cues about how well they understand their reading. If their comprehension is found to be faulty such forms of instructional support also enable students to initiate remedial actions, such as reviews.

Apparently then, requiring or prompting students to review may have served three functions: (a) It may have identified the occurrence of misunderstanding, (b) specified the point in the text where the misunderstanding occurred and, (c) led to substantial increases in the number of sentences re-read, even when review was not mandatory. It remains for further research to determine which of these functions, or which combination was the most important result of prompting or required review.

The superior performance of those who were required and prompted to review confirmed the findings of others (Palincsar & Brown, 1984; Palincsar, 1985; Paris, Cross & Lipson, 1984) that it is possible to teach students to use cognitive processes to make their reading more strategic and, in turn, improve their comprehension. In these other studies students were taught a variety of metacognitive strategies, whereas Experiments II-IV concentrated on the use of review. The findings of this research project suggest that review may be taught as effectively as other metacognitive strategies.

Macroprocessing: Actual and Self-Report.

In Experiments II and III students' awareness of the macroprocesses used was examined. Students were asked to complete self-report forms on various strategies used, and these were compared

to actual macroprocesses used in the experiments. In general, the results indicated that there was little relationship between actual use and self-reports. These findings conflict with those of Alexander et al (1984) who found that observations of students' use of look-backs (re-reading) coincided with their reports. Perhaps, the difference in results may be attributed to the fact that review and other macroprocesses were monitored very exactly, in terms of number of sentences, in this project compared to less precise observational evidence employed in the other research. Students may have some general knowledge about the macroprocesses they use without having a detailed awareness of how intensively they are used.

The discrepancy between self-report and actual macroprocessing use should be followed up in two ways. Students' reports and actual strategy use should be compared in computer displayed text formats, such as that used in this project, and in more conventional reading situations. Such research can determine the variance contributed to the discrepancy by the situation. Another theme worthy of further examination is a comparison between students who do and do not report accurately on their processes. It would be interesting to find out if students who are more aware of their processes learn more, or are more effective in their use of macroprocesses.

The low relationship of self-report and actual use data, and the variability in the use of macroprocesses reported above suggests that students may not know how to use strategies to improve their learning. Since students are rarely taught to use cognitive strategies to help them learn effectively, they may use those strategies they consider most useful. Unfortunately, such decisions may often be based on faulty or vague information, such as test

outcomes. However, students' test scores may be a function of many variables other than the processes used, including total time spent studying, their prior knowledge of a subject, and the quality of instruction. Furthermore, reports of test results are rarely specific enough to give students useful feedback regarding content mastered, and areas requiring further work. In the absence of such diagnostic information, it is difficult for students to relate test outcomes to strategies used. Finally, feedback regarding test results is generally given many days after studying, adding further difficulties to students' attempts to identify useful strategies. Further research varying the specificity and timeliness of feedback may clarify the effects of these variables on students' awareness of macroprocesses used and on their effectiveness.

Relevance to ATIs

All the studies examined a general ATI hypothesis (Tobias, 1976; 1982) predicting an inverse relationship between prior knowledge and instructional method. Specifically, students with minimal prior experience with a subject were expected to achieve optimally with methods providing a high degree of instructional support. On the other hand, students who were familiar with the content to be taught were expected to learn as effectively with methods having less instructional support. The manipulated independent variables in this project were assumed to be forms of instructional support which would be differentially beneficial to students with limited prior experience with the content. The option data were expected to identify the processes by which the independent variables affected outcomes.

The interactions actually found in this project provided only

partial support for the ATI hypothesis described above. It had been assumed that greater instructional support would induce students with limited prior experience with the content to use macroprocesses in general, and review in particular, more frequently to improve learning. Apparently however, the additional instructional support did not induce such students to use the macroprocesses more often. For example, in the first experiment all the ATIs dealing with macroprocesses involved both pretest and worry. In three interactions, students who were high on pretest and worry read and reviewed the alternate text, as well as inspected the headings more frequently than students low in prior knowledge. An interaction in Experiment II indicated that knowledgeable students, who were not required to review voluntarily, re-read more sentences than those with less familiarity with the content. Similarly, in Experiment IV students in the reading group, who were high on pretest, reviewed more sentences than those less knowledgeable. Contrary to expectations, in each of these ATIs knowledgeable students used the macroprocesses more, rather than less frequently, than their less knowledgeable counterparts.

The findings regarding macroprocessing use suggested that the predicted inverse relationship between prior knowledge and instructional support can be expected to occur only when students have been taught, or prompted to use macroprocesses. When macroprocessing use was required or prompted, students with limited prior experience often benefited most from such conditions. On the other hand, when students were free to use macroprocessing options voluntarily, as they were in the first experiment and in some of the conditions of the other studies, knowledgeable students generally

used macroprocesses more frequently, and benefited from them to a greater degree than those with less familiarity with the content, irrespective of the instructional support provided. As indicated above, such instruction occurs infrequently in most school or training situations. Students, therefore generally have little basis for inferring which processes are most efficient. In the absence of instruction, knowledgeable students apparently use macroprocesses more frequently than their less experienced counterparts.

These results suggest that future ATI research may be most fruitfully conducted using training paradigms. That is, once use of cognitive strategies have been trained, it can be assumed that increased instructional support will induce students to use these strategies more frequently. In turn, strategy use can then be expected to facilitate their learning of unfamiliar material. But, on content with which students have considerable prior experience, their existing strategies may be as effective, or more so than those they have been taught. Some support for this generalization was also found in this research program, especially in the interaction between providing explanations and pretest score in Experiment IV (Figure 5.1 on page 5-29). Therefore, for students with limited prior knowledge of the content it can be predicted that instruction in the use of macroprocesses will lead to ATIs in which the frequency of strategy use is increased, its variability reduced, and its effectiveness improved, compared to uninstructed students.

Training Students to Improve Comprehension

The results of this project indicate that requiring or prompting review when there is evidence of comprehension difficulty improves comprehension. These findings suggest that the paradigm to monitor

students' use of cognitive processes may be used effectively for training purposes. An intensive training program could be developed to improve the effectiveness of students' use of review and other macroprocesses. The findings suggest that such intensive training might be especially effective for students for whom a particular content is novel. Training in the use of review, for example, could be developed in which student comprehension is initially monitored by computer and re-reading prescribed when there is evidence of poor comprehension. Continued comprehension monitoring will enable the gradual replacement of external control by giving students a choice of when to review, and finally to shift control entirely to students. The results of this project suggest that such a training program may lead to significant increments in students' comprehension, especially for those with little prior knowledge of the content.

The logic underlying the suggested training program is that when adjunct questions are interspersed throughout a text, the computer can be used to monitor comprehension. Such monitoring permits the rapid identification of misunderstanding, by pinpointing the place in the text causing the difficulty, and permits the implementation of corrective strategies, such as review. It is expected that students can be taught to be more accurate judges of their comprehension when reliance on external monitoring of comprehension is gradually shifted from program to student's control. In turn, students can then learn to use corrective strategies to improve mastery of the content. In addition to teaching effective use of review, this approach is applicable to the development of training in the utilization of preview, use of organizational aids such as headings, or retrieval strategies such as underlining.

In this project, relatively brief instruction about the importance of review, as well as prompting or prescribing review for an average of a little over an hour, improved comprehension. Therefore, a more intensive training program in which students read a variety of passages over a number of sessions can be expected to lead to substantial improvements in comprehension. Such a program will also be very cost-effective for two reasons: First, personal computers will be used to deliver the instruction, with no need for professionally qualified instructors. Second, this project has solved many of the unanticipated programming, technical, and procedural problems that generally arise in the development of computer-based instructional delivery systems. Work on an instructional program can, therefore, concentrate immediately on the development of both the instructional strategy and the materials to implement the model and evaluate its effectiveness.

A cost-effective instructional delivery system, such as that described above, should be of interest in any setting in which effective comprehension of various text materials is required for effective functioning. Obviously, such contexts include school, as well as training sites in the armed forces and in industry. It is recommended that the utility of this model be studied by initially investigating its effectiveness in teaching one strategy, such as review. Once the first program has been completed, training in other strategies such as, use of previews, highlighting, taking notes and others can then be developed.

Table 1. Mean Number of Main Text Reviews

Experiments		Read Only	Optional Review	Required Review
I	Mean	9.9	16.2	-----
	SD	18.2	22.2	-----
II	Mean	17.6	12.3	100.5
	SD	16.4	15.5	39.8
III	Mean	----	80.2	71.2
	SD	----	51.6	41.7
IV	Mean	9.5	77.7	127.1
	SD	14.5	50.1	69.6

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Chapter 2: Experiment I.

THE INTERACTION OF INSTRUCTIONAL METHOD AND INDIVIDUAL DIFFERENCES ON THE COGNITIVE PROCESSING OF INSTRUCTION

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Abstract

This research examined aptitude x treatment interactions (ATIs) among instructional methods and individual differences on both achievement and the cognitive processing (i.e., macro-processing) of instructional material. Individual differences in reading, prior knowledge and anxiety were examined for three treatments (an adjunct postquestions with feedback group, an adjunct postquestions group, and a reading-only control group). The macroprocesses studied included previewing, reviewing, notetaking, use of an alternate text, and use of headings. Multivariate regression analyses of the macroprocesses revealed main effects for treatment and anxiety on the use of the alternate text, an anxiety x prior knowledge interaction for both use of alternate text and use of headings, and an anxiety x prior knowledge x treatment interaction for use of alternate text. These results are discussed within the general framework of prescriptive learning strategies.

INTRODUCTION

Research on the variables accounting for achievement from instruction has offered little encouragement or guidance to empirically oriented educational psychologists. Stephens (1967), for example, reviewed the results of a large number of studies comparing achievement from different instructional methods and concluded that "...in educational investigation one method turns out to be as good as another and that promising innovations produce about as much growth as the procedures they supplant, but no more" (p.10). A more recent review by Montague, Ellis, and Wulfeck (1981) cited similar concerns regarding how little guidance designers can take from a century of instructional research.

In the last few years instructional research has begun to focus on the interaction between individual differences and instructional treatments in an attempt to provide that guidance. This emerging area of research has come to be known as the study of aptitude-treatment interactions (ATI's). The logic propelling ATI research is straightforward: no one instructional method is presumed superior for all types of students. On the contrary, ATI research assumes that students with one set of characteristics, say higher abililty or motivation, may be taught optimally using one instuctional method, whereas others with different characteristics may be taught more effectively another way. Unfortunately, ATI research has produced few replicable interactions (Cronbach and Snow, 1977; Snow 1976; Tobias, 1981a). More puzzlingly, the number of significant interactions

reported has been offset by an equal number of insignificant ATIs (Tobias, 1981a). And all the more disturbing are reports of significant interactions which cannot be replicated, or when replicated produce significant interactions in the opposite direction (Peterson, 1977, 1979).

The purpose of the present research was to bring some order to the study of ATIs by examining some hitherto neglected variables. Therefore, rather than only investigating achievement differences in terms of instructional method, our research also examined the types of cognitive macroprocessing students used while engaged in meaningul learning via microcomputer. The term macroprocesses refers to those relatively molar cognitive processes students use, when learning from instruction, such as reviewing, previewing, seeking clarification, or notetaking. The types of macroprocesses investigated included mental review, organizational strategies, and obtaining assistance and clarification when confused.

For the most part, research in the area of adapting instruction to learner characteristics has ignored macroprocesses. It has been suggested (Tobias, 1982) that learning differences from alternate instructional methods can occur only if they invoke different types of macroprocesses, or use the same macroprocesses with varying frequencies. Not only, then, do these macroprocesses need to be clearly defined and understood, but their relationship to achievement, instructional methods, and individual difference measures - and their interactions - require systematic examination.

In an effort to avoid the methodological problems inherent in the traditional verbal report paradigm used in studies of cognitive strategies (Garner, 1984), this research monitored macroprocessing by using microcomputers. Instructional text was displayed on computers which provided the student with a number of text manipulating options while retaining data on the frequency of their use. For example, mental review was determined by the number and length of text reviews, by student notes taken on the computer, and by student reviews of these notes. The organizational strategies used were determined by examining the frequency with which students previewed the table of contents or previewed the text. Obtaining help and elaboration were indexed by the number of times the student used an alternate, easier version of the text while working on the instructional material.

A secondary focus of this research was on the relationships among anxiety, level of instructional support and the frequency of use of macroprocessing strategies. In the past, ATI research has attempted to demonstrate an interaction between anxiety and those instructional methods assumed to be differentially affected by anxiety. Recent reviews of ATI research, however, point to a need for investigations with stronger theoretical bases. Based firmly in a cognitive view of test anxiety, our research examined the relationship between anxiety and instruction by varying the level of instructional support or assistance provided to the learner (e.g., inserting adjunct postquestions, providing feedback, and allowing for preview and/or review of the instructional material).

It has been suggested, for example, that anxiety does not directly affect instructional outcomes, but, rather, affects the cognitive processes engaged by the instructional treatment, and these, in turn, affect performance (Tobias, 1980). From an information processing perspective, such a model assumes that anxiety interferes with the effective input of instructional material, in addition to affecting learning from instruction at other points (during both the processing and the output stages). It follows, then, that an instructional treatment which permits the learner to process instructional text more effectively will be selectively beneficial to highly anxious learners.

Moreover, in general, prior research suggests that highly anxious learners will engage in more frequent macroprocessing than low anxious students. This expectation derives from an information-processing model of anxiety (Tobias, 1984) which hypothesized that the negative self-preoccupations typically associated with high anxiety absorb some portion of the individual's information processing capacity. Consequently, it follows, that only a reduced proportion of cognitive capacity remains available for processing task related information. It also follows that engaging macroprocesses such as review, and obtaining help or elaboration should be differentially beneficial for the achievement of highly anxious students when compared with their low anxious counterparts. This study tested that hypothesis.

In summary, this study attempted to address the issue of whether anxiety interacts with the level of instructional support provided to the learner. Moreover, the "macroprocess" construct was incorporated into

the design in an effort to detect the specific behaviors (e.g., previewing, reviewing, notetaking) employed by students varying in prior knowledge, reading ability and anxiety. The basic strategy, then, examined: (1) whether varying levels of instructional support were related to achievement; (2) whether there were interactions among the various individual difference measures and instructional support; (3) whether different instructional methods affected the frequency of macroprocessing; and (4) the nature of the interactions among the individual difference measures and the use of the various macroprocessing options.

Review of Research

There are a number of converging lines of evidence supporting the general hypotheses outlined above. These include research on the interaction between prior achievement and instructional method, research on the use of adjunct questions inserted in text, and research on the various cognitive strategies used by students when reading instructional material. Each of these areas of research is discussed briefly in an effort to establish the theoretical perspective guiding this study.

ATI Research

Most ATI researchers seek interactions between instructional methods and cognitive aptitudes such as intelligence or verbal ability. Tobias (1976) suggested that examining the interaction between prior achievement, rather than aptitude, and instructional method may be

more relevant to instructional research for a number of reasons. First, correlations between aptitudes and achievement from instruction vary dramatically over time, a finding most recently demonstrated by Federico (1983) and by Burns (1980). ATIs found at the beginning of an instructional program, then, may be irrlevant once the instructional sequence is underway. Second, it may be difficult to construct alternative methods of instruction by relying only on aptitude differences. Third, the specific psychological processes engaged by a particular content area can be sampled using an achievement oriented pretest, whereas more general aptitude measures may not provide such potentially useful information.

These concerns, among others, led to the hypothesis that the level of prior knowledge is inversely related to the amount of instructional support required to facilitate achievement. That is, students with low levels of prior achievement in a particular content area are expected to require substantial instructional support to accomplish objectives. Conversely, those higher in prior achievement are expected to need little instructional support. Operationally, prior achievement is readily defined by students' pretest scores. Instructional support can be defined as the assistance provided to the learner in terms of organizing the instructional content, eliciting responses, providing feedback regarding those responses and so on.

There is considerable research support for this hypothesis (Tobias, 1977a; 1981; 1982). For example, it has been demonstrated that students with limited prior achievement learned most under

conditions of maximal instructional support, whereas this effect was less marked for students with higher levels of prior achievement. A more detailed review of this literature can be found elsewhere (see Tobias, 1977a; 1981).

It should be noted, though, that support for the prior achievement-instructional support hypothesis has been accompanied by some conflicting evidence (Tobias, 1982) suggesting that other, more subtle variables may be involved. This disparate evidence suggests that external differences between instructional methods may be less important than the way students process the instructional material. These findings led to a reformulation of the achievement-treatment interaction hypothesis.

It was reasoned that for novel content all forms of instructional support would probably enhance students' active attempts to comprehend and organize the subject matter. For such content, providing support should enable students to process the content more deeply than they otherwise could. In such situations instructional support, such as adjunct questions, providing objectives, or similar techniques may improve the ability of students to organize the material. Other support, such as eliciting overt responses, providing feedback, and using advanced organizers may facilitate achievement by making it easier for students to fix their attention on complex, novel content.

On the other hand, on familiar material high levels of instructional support may be unnecessary for a variety of reasons. It is assumed that familiarity reduces the difficulty of the material to be

learned, despite its intrinsic complexity. Support to improve the organization of easy material may then be unnecesary, since students' knowledge of the subject matter may impose an organizational structure. Similarly, the high degree of attention required for novel material is unnecessary when students' have had considerable prior experience with similar or related content areas. For these reasons instructional support is not expected to improve achievement for students with high levels of prior knowledge. Such an analysis suggests that external differences in instructional methods are significant only to the degree that they influence the macroprocesses used by students while engaged in instruction. Research examining the interaction between the level of instructional support and use of macroprocesses may shed light on this issue.

Lastly, recent reviews of ATI research dealing with anxiety (Tobias, 1977a, 1980) suggest that anxiety does not directly affect instructional outcomes. Instead, anxiety affects the cognitive processes engaged by the instructional material and methods, and these, in turn, affect performance. More specifically, this information processing model assumes that anxiety interferes with the effective input of the instructional material, in addition to affecting learning from instruction at other points (i.e., during both processing and output stages). This information processing model suggests that instructional methods which permit the learner to cognitively process the material more effectively will be selectively beneficial to highly anxious students. This research tested this hypothesis as well.

Adjunct Questions Research

In general, the adjunct question paradigm consists of interspersing questions in a passage of text contiguous to the material on which they are based. In a typical study one or two adjunct questions are inserted either before (prequestions) or after (postquestions) a segment of text - usually one or two pages of text. Adjunct questions and the related text segments are presented separately, and the reader is usually not permitted to review the text once it has been presented. Upon completion of the entire passage, a posttest is administered to determine the amount of questioned (relevant) and nonquestioned (incidental) material retained by the readers.

For the most part, studies of this sort have reported consistently that the prequestion group retains about the same amount of material directly questioned (relevant) as the postquestion group (Rickards, 1979), and that both adjunct question groups retain more of the questioned material than a reading only control group (Anderson & Biddle, 1975). This has been called the "direct instructive effect" (Rothkopf, 1966) or the "direct effect" (Anderson & Biddle, 1975). More important, however, these studies have often also demonstrated that a postquestion group recalls more of the text material not actually questioned (an indirect effect) when compared with a prequestion group or a reading only control group.

As Rickards (1979) noted in his review of the adjunct postquestions literature, the paradigm shift to a more cognitive view of learning is evidenced in the number of studies that have used adjunct

postquestions to assess the "depth of processing" or conceptual level necessary to respond correctly (Duell, 1974; Rickards, 1979; and Rickards and DiVesta, 1974). Initially proposed as a framework for understanding human memory (see Craik & Lockhart, 1972), the depth of processing methaphor has come to represent a useful way of analyzing reading comprehension. Within this framework, the "deeper" (i.e., more semantic) the processing, the better the comprehension.

Despite the relative abundance of studies using adjunct postquestions, few investigations have been directed at the effects of individual differences on the effectiveness of adjunct postquestions inserted in text. These individual difference - adjunct qustion studies have, for the most part, employed the ATI paradigm. Rothkopf (1972) reported that low ability students (i.e., those with ineffective reading skills) achieved more in the adjunct questions conditions when compared to a group without adjunct questions, as expected from the achievement - treatment hypothesis (Tobias, 1977b). The lower ability students, Rothkopf argued, were aided in terms of increased inspection rates (attention to text) produced by the insertion of adjunct postquestions.

Hiller (1974) varied two sets of inserted postquestions designed to have different levels of readability. Individual differences in verbal ability, anxiety and self-confidence were also examined as they interacted with four treatment levels: (1) relatively easy inserted post-questions; (2) relatively difficult inserted postquestions; (3) passive reading; and (4) idiosyncratic study. The scores on an immediate retention test for the difficult postquestion group reading the difficult

lesson were correlated positively with self-confidence and negatively with test anxiety. Thus, learning was correlated with anxiety and self-confidence for the two treatments in which the text had lower than average readability, but not in the average readability level treatment.

Shavelson, Berliner, Ravitch, and Loeding (1974) attempted to extend the study of the interactions between individual differences in aptitudes and instructional treatments by manipulating the position and type of questions inserted in prose material. Five aptitude measures were administered: (1) vocabulary; (2) hidden figures test for general ability; (3) letterspan or recall for letters; (4) Taylor Manifest Anxiety (Taylor, 1953); and (5) memory for semantic implications. Total and incidental learning scores were regressed on the aptitude measures to test for ATI's. No interactions between memory ability, measured by the letterspan and semantic implications tests, and treatments were found. Moreover, anxiety and the hidden figures test also did not interact with the treatments. The vocabulary score did interact with the treatments on both the immediate and the delayed retention test indicating that higher order adjunct questions placed after the text facilitated the performance of subjects with low vocabulary scores.

The studies presented above have varied with respect to the individual difference dimensions investigated. Despite these variations, one salient point has emerged: the more support the adjunct question treatment provides to the learner, the greater the achievement. When students are asked questions that are directly relevant to the material to be learned, their achievement increases. When adjunct postquestions

lead to increased attention, that treatment, in turn, produces increased learning.

Student Review Strategies

The majority of studies using adjunct questions have included instructions to the subjects not to review the text. However, Gustafson and Toole (1970) permitted review and allowed their subjects to study a passage for as much time as they wished. Their results were, in general, consistent with the basic findings of a mathemagenic effect reported by Rothkopf (1967, 1972). The ability to attend selectively to, and presumably review, the questioned material produced a substantial improvement in intentional learning and a small improvement in incidential learning for the adjunct question group. Unfortunately, this investigation did not report the freqeuncy of review by students. Thus, conclusions drawn about the precise role of review as a learning strategy in this study are tenuous.

However, more recently there has been a surge of interest in the cognitive strategies used by students while reading instructional material (Alvermann and Van Arnam, 1984; Garner, 1984; and Garner and Reis, 1981). For example, Garner and Reis (1981) investigated reading "lookbacks", i.e., reviewing previously read material, among good and poor readers in grades 4 thru 10. Reviewing was explicitly encouraged, and the investigators monitored the lookback behaviors. Their results indicated that only the older good readers used the reviewing strategy with any frequency or degree of success.

In a further study, Alexander, Hare, and Garner (1984) investigated review strategies among older (undergraduates), proficient readers. Prior to instruction subjects were asked what strategies they would use on a task that required reading a passage and answering subsequent questions. After the instructional task, subjects were then asked what strategies they actually used. It was reported that those who said they used a particular strategy (e.g., underlining or reviewing), actually did so and, conversely, very few subjects used a strategy that they had not previously reported. However, the rather surprising result of this study was that more than half (29 out of 52) of these older, proficient readers failed to review the text at all. The authors noted that this may be an artifact of their design, since many students reported that they thought they were not permitted to look-back or review the material.

Alvermann and Van Arnam (1984) used an ATI paradigm to examine the relationship between reading ability and induced review. Their results suggest that poor readers were assisted by increased levels of instructional support (i.e., the use of graphic organizers). Moreover, the inducement of review or "lookback" behaviors was reported to have resulted in superior performance for poor readers. These findings, particulalry since no treatment differences were reported for good readers, lend support to Tobias' (1977a) achievement x treatment interaction hypothesis discussed earlier.

In general, the literature on reading comprehension suggests that there are quantitative and qualitative differences in both metacognitive

and reading comprehension skills and strategies between good and poor, as well as older and younger, readers. However, there is some evidence that even experienced, good readers do not routinely use some strategies thought to be in their reportoire (Alexander, Hare, & Garner, 1984). Clearly, more research is needed identifying use of reading strategies and their relationship to student characteristics.

Summary

ATI research relating prior achievement and instructional support has, in general, confirmed the hypothesis of an inverse relationship between these variables. That is, generally, students with little relevant prior experience typically profited most from instructional methods offering substantial instructional support, whereas such support was often of little benefit to students with high levels of relevant prior experience. Conflicting findings in this area, and in ATI research in general, have led to an emphasis on the cognitive processes engaged by instructional methods and by student characteristics. A tacit assumption of that approach is that the psychological processes engaged by instructional methods may lead to more consistent results than the more superficial characteristics of instructional methods.

Research has also indicated that adjunct questions are an important source of instructional support in that they typically improve the achievement of students on material relevant to the content of the questions. While there has been a good deal of speculation about the mechanisms by which adjunct questions achieve their effect, little direct evidence regarding these questions is available.

As noted earlier, there have been a number of studies reported recently which purport to examine the relationship between achievement and the cognitive strategies used by students while reading. For the most part, in order to examine these strategies researchers have relied on two methods: interviews and "think-aloud" procedures. Both have been classified as "verbal report methods" (Garner, 1984) and not surprisingly, both have been widely criticized. In general, these criticisms revolve around the historical issues associated with introspective techniques, such as reliance on students' verbal ability and the tendency of students to report the use of strategies they beleive they ought to have used (see Garner, 1984 for a more detailed treatment of these issues).

The research reported here attempted to avoid these methodological problems by monitoring the use of cognitive strategies by students. Thus, the aim of this study was first to determine whether different instructional methods, such as providing text augmented with adjunct questions, or questions with feedback, induced students to use different macroprocesses while reading. Further, we also investigated whether students of different characteristics, i.e. varying levels of prior achievement, reading ability and anxiety used different instructional methods. Finally, we examined whether the results substantiated an interaction between the preceding questions.

METHOD

Students were randomly assigned to read an instructional text displayed by microcomputer in one of three different methods. In each condition students could use a variety of options to facilitate study of the text. Individual difference data, including measures of reading ability, prior knowledge of the content, and anxiety were administered to students.

Subjects

Volunteers for this experiment were recruited from the student population of the City College of New York. A total of 120 S's participated in the study. The sample was comprised of 68 males and 52 females with a mean age of 21. Students were paid $12 for their participation.

Pilot Study

In a preliminary study 47 students were asked to "list all of the study techniques you use in learning from textbooks, articles and the like." Student responses were submitted to content analysis and the single most prominent strategy appeared to be reviewing, followed by underlining, preparing summaries taking notes, skimmming, obtaining extra help by use of dictionary, and consulting title headings. The equipment available, Apple II microcomputers, prevented implementation of the underlining strategy, though as many of the others as possible were used in this investigation.

Procedures

The instructional materials were presented using Apple II Plus microcomputers. The time subjects spent reading each text segment, along with their responses to all questions, were recorded automatically by the computer. In addition, the computer recorded each use of the macroprocessing options to be described below.

Subjects were randomly assigned to one of three instructional treatments: (1) a reading only control group; (2) an adjunct postquestions group; and (3) an adjunct postquestions with feedback group. Postquestions required a constructed response and were presented after each screenful of text, i.e., two or three paragraphs. Subjects' responses were evaluted by the computer and three classes of feedback were provided: (1) subjects were informed that their response was identical to the answer provided in the text; (2) the response was similar to, or equivalent to one provided in the text; and (3) the response appeared to be incorrect and the correct response was provided.

The procedures were administered in two sessions. In the first session subjects were given a pretest covering the instructional material to be presented subsequently (Cronbach's Alpha Reliability = .75), the Nelson Denny Reading Test (Brown, et al., 1981), the Test Anxiety Scale (Sarason, 1972), four subtests of the Learning Study Skills Invetory (Weinstein, 1982), and the Worry-Emotionality Scale (Morris et al., 1981) with instructions to complete it in terms of the way they felt at that moment. These materials were administered in group settings ranging from three to 35 subjects.

In the second session students were assigned to microcomputers to study the text. When students completed one half the instructional material the Worry-Emotionality Scale (Morris et al., 1981) was administered on the computer with instructions to respond they way they felt while studying the material. Upon completion of the instructional material, each subject completed a paper and pencil posttest requiring fill-in answers (Cronbach's Alpha Reliability = .92) and another version of the Worry-Emotionality Scale with instructions to report how they felt while working on the posttest.

Instructional Text

The instructional material consisted of 22 screenfuls of text, 173 sentences making up forty-nine paragraphs. The text presented some major concepts of data processing, computer programming, and a sample of illustrative commands of the BASIC programming language. Each of the 173 sentences in the text was numbered and exposed one at a time. When a sentence was read and the space bar depressed, it was erased though the space it occupied and its number remained.

Following suggestions by Garner and Reis (1981) the text was designed with several criteria in mind. It was written at a level which both good and poor readers could decode and comprehend. It was information-laden so that a reasonable number of questions could be generated to test comprehension on a posttest. The material was designed so that it could be presented in segments to allow for interspering of adjunct postquestions and, lastly, the text was sufficiently detailed to induce the use of the various macroprocessing options.

The text was estimated to require a 14th grade reading level (Fry, 1969). An alternate, easier version of the text was constructed which had the same content in every paragraph as the main text, but used an easier vocabulary, i.e., the 10th grade according to the Fry (1969) formula. The alternate text also was structured so that superordinate concepts and sentences preceded subordinate ones to a greater extent than in the main text.

Options

All students could choose any of these options while reading the text: they could (1) review, or (2) preview any sentence, or group of sentences; (3) consult the alternate version of the text after completing a paragraph. 4) The alternate text could be reviewed, or (5) previewed. 6) Students were able to take notes on the computer system, (7) and review their notes. 8) An organizational display could be requested containing all the headings in the main and alternate texts, the sentence numbers covered by each heading, and the number of the sentence students were presently reading. 9) A menu of the options available, and how they could be invoked could also be requested.

The options described above could be invoked by students at any time during the course of the presentation with two exceptions: (1) the adjunct question group could invoke the options only after they had responded to the question; and (2) the alternate version of the text could be requested only after a complete paragraph had been read. A beep was sounded by the computer at the end of a paragraph signaling that the alternate version of the text could be consulted.

Prior to the beginning of the instructional presentation, a description of each of the options was provided. The description required students to use each option at least once to ensure familiarity with the procedures prior to instruction. After the first few introductory remarks, the descriptive material followed the same structure as the ensuing instructional material, i.e., each sentence was numbered and presented one at a time and the space bar on the computer's keyboard had to be depressed to produce the next sentence.

RESULTS

Table 1 displays the means and standard deviations for the major independent and dependent variables in this study, as well as descriptive data on the sample.

Insert Table 1 here

The means and standard deviations for the macroprocessing options, and the percentage of students not employing any of the options are displayed in Table 2.

Insert Table 2 here

The standard deviations for the macroprocessing data indicated they were very varied. In order to reduce the effects of outliers the data for students whose use of any of these options fell over three standard deviations above the mean was set at the third standard deviation value. Despite that, it is evident that the variability was still very large. The posttest was divided into two sections: those items related to any of the adjunct postquestions (i.e., relevant items), and those unrelated, or incidental to the adjunct postquestions. Table 2 also displays the correlations of each of the options with the incidental, relevant, and total posttest score.

Multivariate regression analysis results of the posttest are displayed in Table 3.

Insert Table 3 here

As expected, pretest and vocabulary contributed significantly to posttest scores on both the relevant and incidental items. Also as expected, there were significant differences among groups in achievement on both the relevant and incidental portions of the posttest. Both groups receiving adjunct postquestions outperformed the reading only control group on the posttest. There was also a main effect attributable to worry, a component of test anxiety (Morris, et al., 1981), on the incidental portion of the posttest, indicating that anxious students learned less than those lower in anxiety.

Surprisingly, multivariate regression analysis uncovered no interactions among these variables.

Multivariate regression analysis results of the macroprocessing option data are displayed in Table 4.

Insert Table 4 here

This analysis indicated a difference among the three groups for the frequency of overall option use, with significant univariate effects for use of the alternate text and notetaking, in particular. In general, the group receiving adjunct postquestions and feedback used the macroprocessing options least frequently, while the adjunct postquestions only group used the options most. A main effect for worry was found for the alternate text option indicating that the more anxious students tended to use the alternate, easier version of the text more frequently than less anxious students.

The analysis of the macroprocessing data also produced a number of significant interactions. For example, a significant pretest by worry interaction was found for use of both the alternate text and headings options. These interactions are displayed in Figures 1 & 2 below.

Insert Figures 1 & 2 here

It should be noted, here, that deviation scores for both anxiety and prescore were computed and used in the regression analyses and are represented by the x axis in the figures. The use of deviation scores has been recommended to reduce the effects of multicollinearity among predictor variables (Cronbach and Snow, 1977).

In addition, a significant triple interaction of treatment by pretest by worry was found for the alternate text option. This interaction is depicted in Figure 3.

Insert Figure 3 here

Interestingly, the shape of the interaction between prescore and anxiety is essentially the same for both the feedback and the control groups, while the postquestions only group had a more or less parallel slope for the anxiety regression line but a steeper slope for the prescore regression line. The interaction between anxiety and prescore for both the feedback and control group is quite similar, while for the postquestions only group the influence of prescore was much stronger.

DISCUSSION

The significant differences on both the relevant and incidental items of the posttest confirm prior findings that adjunct postquestions facilitate achievement on material which is both incidental and relevant to the content of the question. In this study the two groups receiving

questions outperformed the reading-only control group both on relevant and incidental items of the posttest. Of some interest was the fact that the adjunct question group had slightly, though not significantly, higher scores than the group receiving feedback. Perhaps the presence of feedback led this group to process the text less thoroughly than the adjunct postquestion only group.

The most surprising aspect of the macroprocessing data was the incredible variability with which the macroprocessing options were employed. The percentage of students who did not use an option at all varied from 18% to 88%. Despite this low mean frequency of usage, a number of students used these options very often indeed. The standard deviations of the frequency data are often two and three times higher than the mean! Clearly, there was incredible variability in the frequency with which options were used.

There was a significant difference among the groups in terms of the frequency with which options were used. In general, the group receiving feedback used the options least often, and the adjunct question group most frequently. These results appear to suggest that the group receiving feedback may have had little need to use the options due to the information provided by the feedback. That is, it may have been unnecessary for these students to use the review option, for example, in order to determine the correct answer, since it was supplied to them. The large mean differences on use of review supports this thinking. Presumably, these students were similarly less motivated to employ the other options provided. This aspect of the

results confirms Tobias' (1982) expectation that it is instructionally unsound to do for students what they could do for themselves, i.e. supply their own confirmation as to whether answers are correct or not. Apparently, by providing feedback these students were less active in their reading of the text, at least as determined by the frequency of macroprocessing use.

Interactions

The interaction between prescore and anxiety on the number of alternate text sentences read indicates that the more anxious students tended to read more alternate sentences than those lower in anxiety. This finding can be expected from a formulation (Tobias, 1984) suggesting that anxiety absorbs some portion of cognitive capacity, leaving less capacity for task solution. Use of the alternate, easier text may well have been less demanding of cognitive capacity for these subjects, hence, as anxiety increased they attempted to reduce the cognitive demand the main text passage called for by consulting the less demanding alternate passage. The number of alternate sentences consulted had an essentially flat relationship with prescore, indicating little variability attributable to the amount of prior knowledge. A similar interaction was found for frequency with which the headings were used, though the magnitude of this interaction was substantially smaller than that involving the alternate text.

A triple interaction was also found for the number of alternate text sentences read by students. This interaction involved anxiety, prescore, and instructional method. In general, the number of

sentences read were unrelated to prescore for the control and feedback groups. For the adjunct postquestion group, however, as prescore increased the tendency to use the alternate text also increased. Presumably, students in this group were uncertain regarding the correctness of their answers to the adjunct postquestions and, hence, felt some need to consult the alternate, easier text. Surprisingly, the more knowledgable the student about the subject matter, as reflected in the prescore, the more likely they were to consult the alternate text. The interaction involving anxiety had a similar slope for all three instructional groups, i.e., as anxiety increased there was a tendency for the number of alternate text sentences read to increase as well. The rationale for this finding has been described above.

Option Use

A surprising finding was the fact that, in general, students use of macroprocessing options had only limited relatioships to their postest scores, see Table 2 for correlations , and similarly limited relationships to reading ability. It was assumed that students would invoke some or all of the options to help them learn the material more efficiently, and that use of these options would be positively related to outcomes. Instead, the findings suggest that option use frequently was not in the service of increasing comprehension.

There are two possible interpretations of these data. The first of these is that students may not have been particularly motivated to do well on this task. This interpretation would suggest that students used the options out of curiousity regarding how they worked, rather than

to improve their learning. The mean achievement scores tend to contradict this interpretation. The total possible number of points on the posttest was 46. The percentage correct for the two postquestions groups was approximately 70%, a reasonably high score on a difficult test. It is conceivable that a highly motivated group may have done much better, though these data do not suggest an absence of motivation as a major interpretation of these results.

The alternative interpretation has to do with the fact that students may not know which instructional strategies are especially effective for improving their performance. The high variability of option use, and the low relationship with posttest scores and reading ability tend to support this interpretation. Students are rarely instructed, at any educational level, regarding how to improve their learning and studying. While students indicated frequent use of review in the pilot study, the data for number of sentences reviewed tell a different story. The feedback and control groups reviewed approximately 5% of the sentences, and the adjunct postquestions group reviewed about 9%. This was not a high percentage of reviews, in view of the fact that the mean posttest score indicated a good deal of room for improvement.

Prescriptive Use of Macroprocesses

An interesting question arising in this context is what would be an ideal use of options? That is, how frequently should good or poor readers use these options? The present data do not answer this question satisfactorily, since the median correlation between the total

frequency of option use and total posttest score was only -.03 for the feedback group, and .14 for both the adjunct question and reading-only group. Clearly, such correlations do not warrant recommendations regarding ideal use of instructional options.

The study does, however, offer an interesting model in order to determine what could be ideal use of options. Though there was variation among the treatment groups, in this investigation the frequency of options used correlated positively with the total posttest score. Analyses of these correlations may be useful in building a model of ideal option use. That is, if option use is highly correlated with achievement, then such use should be recommended. Furthermore, the presence of data regarding students' prior achievement, reading ability, and anxiety permits the computation of partial correlation coefficients in which the contributions of these variables can be studied in further research. It follows, then, that the use of correlational analyses is potentially powerful for making recommendations regarding ideal option use.

In future research it may be useful to assist students with option selection. It would appear that students should review the preceding text in those instances when their answers to an adjunct question are wrong. In that way they may be able to correct their misconceptions prior to moving on to suceeding text. A future study, for example, might examine the effect on the learning outcomes of some students, say those with low pretest scores, of prescribing use of the review option. If use of review in these situations does, in fact, raise achievement,

one can then envision a suceeding study in which students are taught this general strategy while their performance is monitored on tasks similar to those used in this experiment.

Table 2.1
Means and Standard Deviations of the Pretest, Posttest and Anxiety Scores by Treatment Group.

Variable		Adjunct Q Feedback	Adjunct Q Only	Control Group
Pretest Incidental	M	8.34	8.51	7.74
	SD	3.74	2.87	3.03
Pretest Relevant	M	11.10	12.26	11.37
	SD	4.43	3.82	3.38
Pretest Total	M	19.45	20.77	19.12
	SD	7.41	5.77	5.45
Test Anxiety Scale	M	17.00	17.97	19.44
	SD	6.46	8.28	6.35
Worry Scale	M	9.24	9.62	9.33
	SD	3.91	4.66	4.04
Emotion Scale	M	7.53	7.03	8.05
	SD	3.68	2.58	3.56
Posttest Incidental	M	13.14	14.84	11.99
	SD	5.40	5.86	5.05
Posttest Relevant	M	17.56	17.90	13.91
	SD	5.28	6.00	5.16
Posttest Total	M	19.45	20.77	19.12
	SD	7.41	5.77	5.45

Table 2.2

Means and Standard Deviations of the Frequency of Macroprocess Option Use by Treatment Group.

Variable		Adjunct Q Feedback	Adjunct Q Only	Control Group
Previews	M	1.05	1.74	1.63
	SD	2.51	3.54	3.04
Reviews	M	9.55	16.23	9.93
	SD	20.06	22.24	18.19
Alt. Text	M	4.74	37.50	15.40
	SD	13.04	47.32	27.48
Review Alt. Text	M	2.28	4.49	3.46
	SD	10.36	9.94	9.75
Notes	M	3.79	5.54	9.10
	SD	5.98	7.67	10.97
Review Notes	M	0.29	0.69	0.92
	SD	0.96	1.09	1.64
Headings	M	0.58	0.92	1.38
	SD	1.11	1.53	1.93

Table 2.3

Results of Multivariate and Univariate Multiple Regression Analyses of the Posttest Scores.

N=112	WILKS[1]	UNIVARIATE F's	
		PostRel	PostInc
Treatment	5.12*	8.12*	3.36°
Pretest	15.83**	29.95**	25.51**
Worry Scale	2.03	2.28	4.09°
Trt * Pretest	-	-	-
Trt * Worry	-	-	-
Pre * Worry	-	-	-
Trt*Pre*Worry	-	-	-

1. Approximate transformation to the F distribution. F values less than 1 not reported.

** signif LE .001 * signif LE .01 °signif LE .05

Table 2.4

Results of Multivariate and Univariate Multiple Regression Analyses of the Macroprocess Options.

N=120	WILKS[1]	UNIVARIATE F's						
		Rev.	Alt.	Rev.Alt.	Notes	Rev.Notes	Hdgs.	Prev.
Treatment	2.88**	1.4	11.54**	-	4.06°	2.42	2.87	-
Pretest	-	-	1.46	-	1.62	3.12	2.5	-
Worry 2	1.8	2.73	3.67°	2.90	-	-	2.76	1.95
Trt*Pre	1.3	2.0	-	2.49	-	-	2.08	2.11
Trt*Worry	-	-	-	-	-	-	-	-
Pre*Worry	2.04°	-	10.78**	-	1.10	-	4.06°	1.87
T*Pre*Worry	1.33	2.56	4.47°	-	2.39	-	2.86	1.77

1. Approximate transformation to the F distribution.
F values less than 1 not reported.
** signif LE .001 * signif LE .01 ° signif LE .05

List of Figures

Figure 2.1 Response Surface Plot of the Interaction of Anxiety (Worry) and Prior Knowledge on the Use of the Alternate Text.

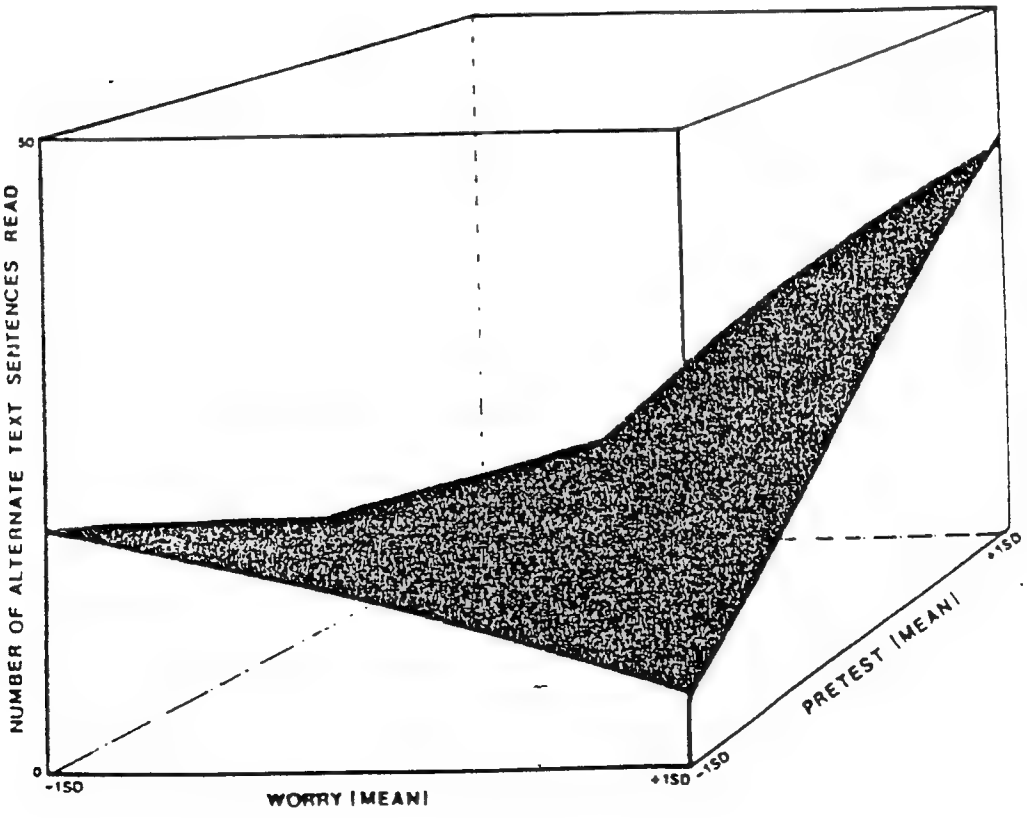


Figure 2.2 Response Surface Plot of the Interaction of Anxiety (Worry) and Prior Knowledge on the use of Headings.

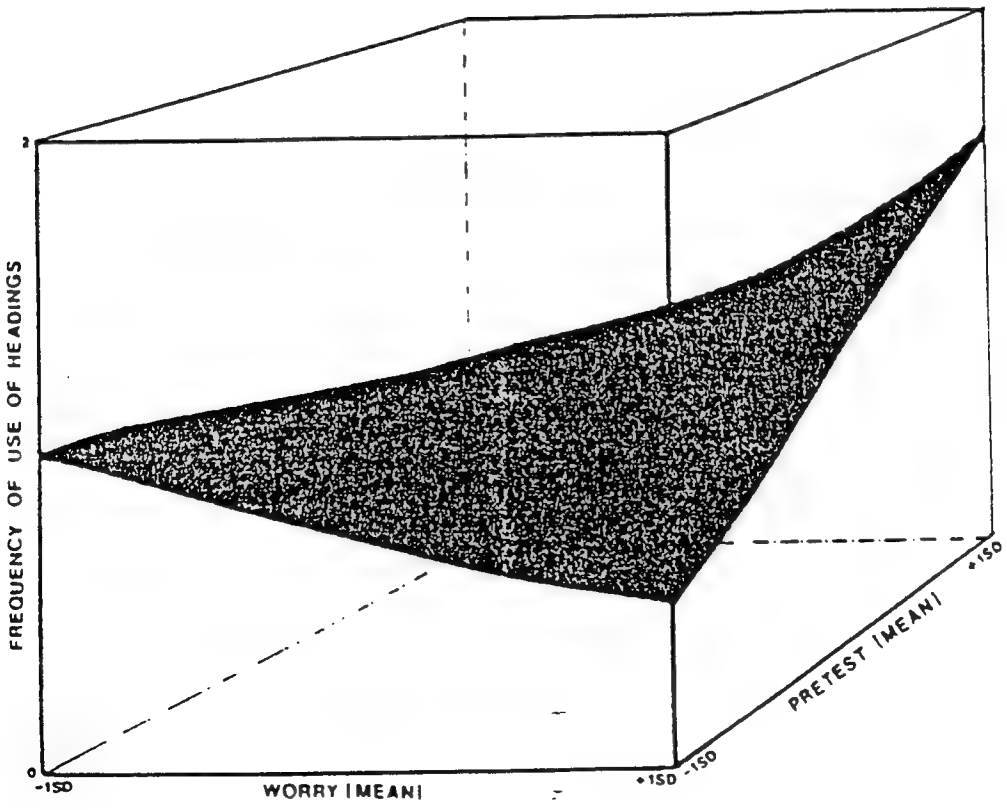


Figure 2.3a Response Surface Plot of the Interaction of Anxiety (Worry) and Prior Knowledge on the Use of the Alternate Text for the Adjunct Question/No Feedback Group.

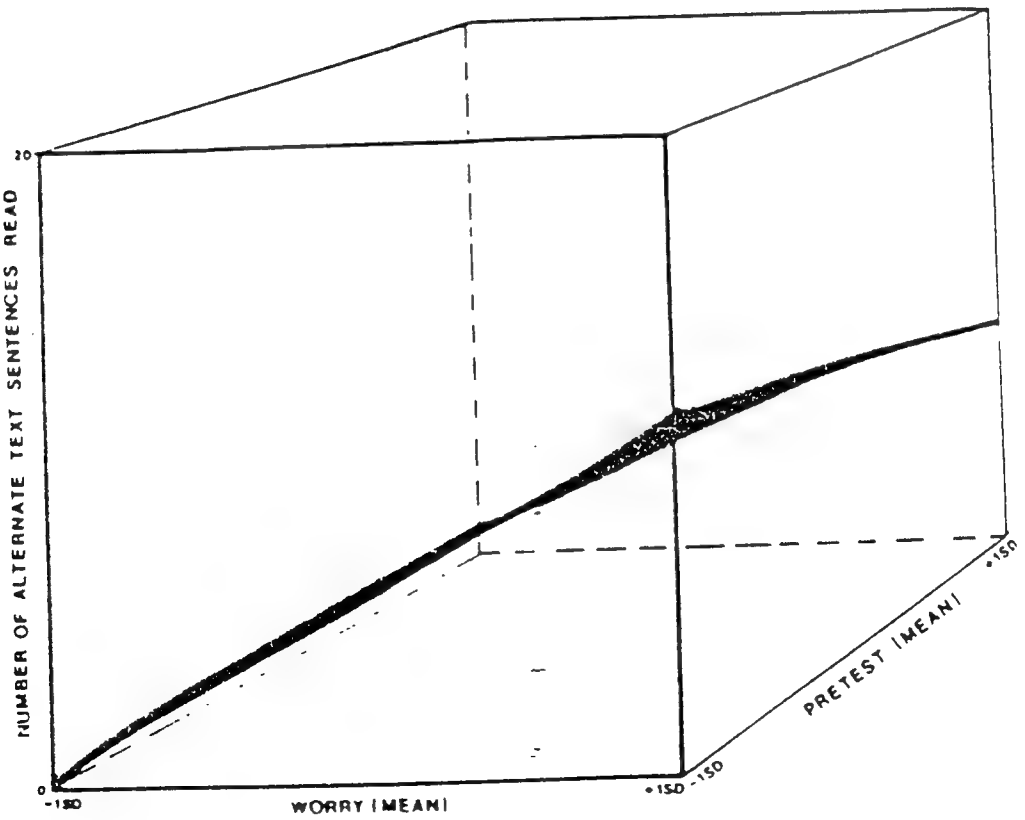


Figure 2.3b Response Surface Plot of the Interaction of Anxiety (Worry) and Prior Knowledge on the Use of the Alternate Text for the Adjunct Question/Feedback Group.

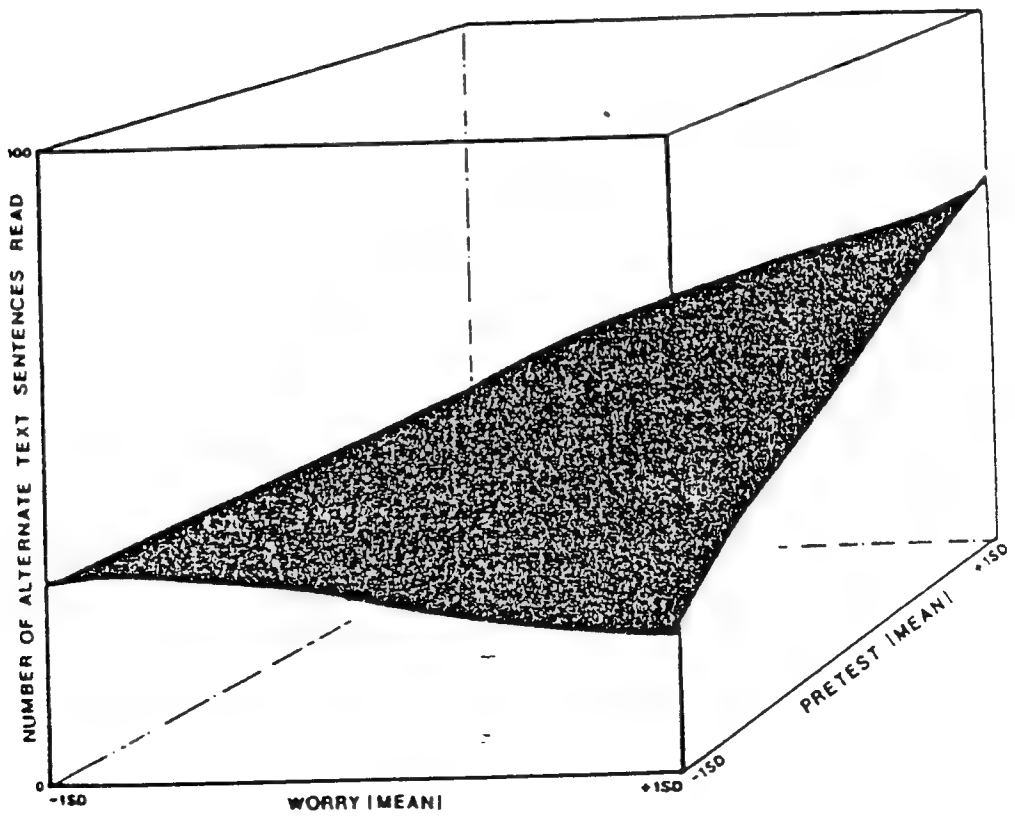
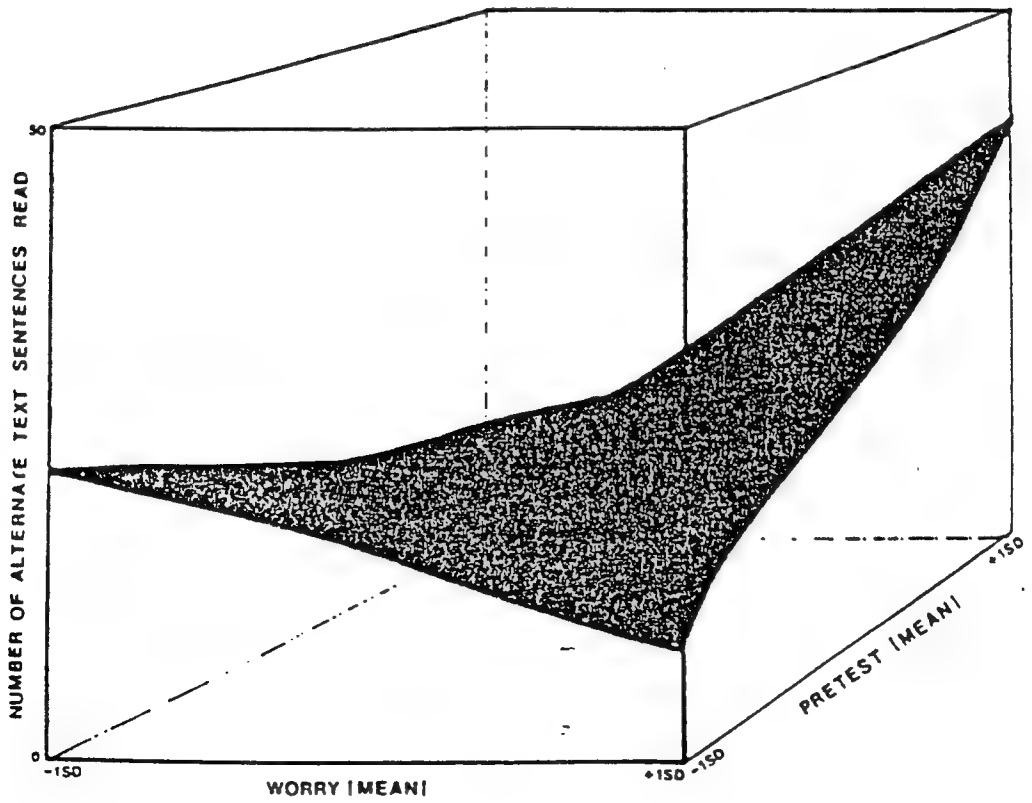


Figure 2.3c Response Surface Plot of the Interaction of Anxiety (Worry) on the Use of the Alternate Text for the Control Group.



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Chapter 3. Experiment II.

OPTIONAL AND REQUIRED TEXT REVIEW STRATEGIES AND THEIR INTERACTION WITH STUDENT CHARACTERISTICS

Sigmund Tobias

Abstract

A total of 140 students was randomly assigned to read a text passage displayed on microcomputers in one of four conditions: 1) Required review of main text if response to adjunct questions was incorrect. 2) Required review of an alternate, easier text if the response to adjunct questions was incorrect. 3) Optional review. 4) Read-only without adjunct questions. In each of the conditions students also had access to a number of other macroprocessing options. The results indicated that the required review groups outperformed the others on text relevant to the adjunct questions and, also differed significantly from the other groups in the number of review. Significant interactions among treatment, prior achievement and anxiety measures were also obtained. Students' self-report of reading strategies were found to be unrelated to options use. The results are discussed in terms of students' knowledge of useful reading activities.

Introduction

Recent research has indicated that readers engage in less strategic behavior than expected. Evidence from a number of areas has also suggested that reader's use of strategies has been fairly inconsistent, often ineffective, and unrelated to various student characteristics. The purpose of this study was to examine the effects of prescribing the use of some reading strategies on comprehension. The effect of such prescription on the interactions among instructional method and a number of individual difference variables were also investigated.

Review of the Literature

In a preceding study (Tobias, 1984a) a variety of reading strategies including review, taking notes, consulting an easier passage, and others were available to students reading a passage dealing with data processing that was displayed on microcomputers. Students could invoke these strategies as options at any time during their reading and use them as frequently as they wished; option use was monitored by microcomputer. Enormous variability in the use of instructional options was found. Standard deviations were often two and three times the size of the means, and the percent of students using any of nine options ranged from a high of 82%, to a low of 12%. Correlations between frequency of option use and posttest scores were quite low and generally non-significant, raising question as to whether options were used to improve comprehension. Finally, correlations with individual difference measures, such as reading scores, state and trait anxiety indices, or measures of prior knowledge were also found to be low.

Similar reports of inconsistent use of reading strategies have come from a number of research projects. For example, Markman (1979) examined the awareness of text inconsistencies among students in third to sixth grade and found that the majority of this group did not detect inconsistencies even when told to lookout for them. Garner and Kraus (1981-82) found that 4 out of 15 seventh grade good readers were able to detect inconsistencies between sentences. Baker and Anderson (1982) also used a similar paradigm in which students read text displayed on microcomputers. They found that only 31% of this college student sample re-read a sentence that preceded a main point inconsistency, and only 16% re-read sentences that preceded a detail inconsistency. Furthermore; 49% of their students did <u>not</u> report either one or both inconsistencies.

Infrequent use of reading strategies has also been reported in studies of student review or "lookbacks". Garner and Reis (1981) found that only 30% of seventh grade good readers looked back at prior text in order to answer questions. Only 9% of the poor readers did so. Alexander, Hare, and Garner (1984) found that for college students who were good readers only 30% looked back at preceding text and that 50% never looked back under any conditions. Their results also indicated that strategies reported by students were actually

used by them.

Hare and Smith (1982) used sixth and seventh graders to investigate reading strategies. No student reported use of more than two strategies, and a negative relationship between recall and number of strategies reported was found. Meyer, Brand, and Bluth (1980) found that good readers used text structure strategies to aid recall more frequently than poor readers. However, less than 50% of their subjects used the strategy more than once, and only 22% of their subjects used such strategies consistently on four separate protocols. Nist and Hogrebe (1984) reported ineffective use of both adjunct questions and headings among 103 college students. That is, use of these aids seemed not to have affected reading achievement.

While these findings demonstrate infrequent, variable, and ineffective use of strategies by students, other research has indicated that training students to use various strategies has been effective in improving comprehension. Palinscar and Brown (1984) found their reciprocal teaching paradigm successful in helping students acquire metacognitive strategies. Stevens (1983) reported generalization effects from a metacognitive strategies teaching program. Weinstein and Rogers (1984) developed a college-level program to teach students to monitor comprehension and use learning strategies. They reported increased scores on a standardized measure of vocabulary and reading comprehension, as well as greater retention of course material.

Garner, Hare, Alexander, Haynes, and Winograd (in press) taught remedial readers (mean age 11 years, 2 months) why, when, and where to use a lookback strategy. Testing five days after instruction indicated that students used lookbacks when needed and were significantly more accurate on lookback questions than the control group of remedial readers. Alvermann and Van Arnam (1984) found that a graphic organizer, which redirected the reader to the appropriate text in order to answer questions, facilitated the achievement of poor comprehenders.

These reports indicated that when students were either taught or prompted to employ reading strategies, use of these became more effective compared to an environment in which strategy use was left entirely to students' initiative. Therefore, it was hypothesized that learning would improve if students were required to review text when they experienced comprehension difficulties, compared to a condition in which strategy use was optional.

One of the reasons for variable and ineffective use of reading strategies may be that students are <u>not</u> completely aware of the strategies actually used. The options made available to students in a preceding experiment (Tobias, 1984a) were based on the results of a pilot study in which students were asked to list the reading strategies employed. With the exception of underlining, which was difficult to implement on the computers employed in the study, the most frequently listed strategies were made available to students in the experiment. Even though the pilot sample claimed to use these strategies frequently, the experimental sample generally employed

them infrequently and ineffectively. In contrast, Alexander et al. (1984) found that student reports of strategies used coincided with observer reports in most cases (17 out of 19 self-reports of lookbacks). Since text was again displayed by microcomputer in the present study, more precise data on strategy use than available to Alexander et al. could be collected. As indicated previously, student use of options was monitored by computer. These data will be compared to self-reports, in order to clarify students' awareness of their strategy use.

Adjunct Questions

It was assumed in both the preceding (Tobias, 1984a) and in the present study that one way to induce students to monitor their comprehension carefully was to ask adjunct questions about some of the material they had read. A substantial body of research (Anderson & Biddle, 1975; Rickards, 1979) has indicated that such questions improve student comprehension. It was expected that answering adjunct questions would prompt students to use a variety of reading strategies more frequently, leading to improved achievement.

The results of our prior study (Tobias, 1984a) supported the expectation that adjunct questions would result in more active processing and improved achievement. Students answering adjunct questions learned more than a read-only group and took notes more frequently, in addition to reading an alternate, easier version of the text passage more often. While a large number of studies employ adjunct questions, students are rarely permitted to review their reading in those investigations. The results of the few studies permitting review (Gustafson & Toole, 1970; Schumacher, Moses & Young, in press) indicated that achievement was increased by reviewing.

Anxiety and Achievement Treatment Interactions

This study was also stimulated by research from two other areas: 1) investigations of the effects of test anxiety on learning, and 2) ATI research, that is, studies of the interaction between individual differences and instructional treatments. Research on anxiety, summarized elsewhere (Tobias, 1984b), has indicated that anxious students are more likely to use review procedures and to benefit more from their use than those less anxious. An explanation for these findings is that review is especially beneficial to anxious students, since their attention is more frequently diverted from the task to a variety of negative self-preoccupations than is the attention of less anxious students (Wine, 1971; Sarason, 1972). Having the opportunity to review, therefore, enables anxious students to redirect their attention back to the task and thus compensate for the effects of anxiety. There is some research (Tobias, 1984b) to support this hypothesis.

ATI research assumes that no one instructional method is optimal for all types of learners. Instead, it is hypothesized that some instructional methods are ideal for some students, while others may be optimal for students with different characteristics. This

research, reviewed at length by Cronbach and Snow (1977), has been characterized by a number of problems (Tobias, 1982,1985), including lack of generality for some results, inability to replicate others, and an approximately equal number of positive and negative findings. It has been suggested (Tobias, 1982) that different instructional methods can lead to changed outcomes in two ways: 1) if students employ different cognitive processes or macroprocesses, or 2) if the same macroprocesses are used less frequently in some methods than others. In terms of the present research, then, it was expected that variation in achievement would occur only if there were differences in the frequency with which students in the various conditions employed macroprocessing options, or if they used different types of macroprocessing options.

Finally, a general ATI hypothesis (Tobias 1976, 1982) predicted that prior achievement had an inverse relationship to the amount of instructional support available in different methods. That is, students with little familiarity with an area were expected to need substantial instructional support to learn, whereas more knowledgeable students require less support. Instructional support has been defined as the assistance given to students in encoding, storing, organizing, and processing instructional input. In the present study, then, it was expected that students with low prior knowledge of a subject would use instructional support (i.e., the macroprocessing options) more frequently than those with higher prior knowledge.

Method

Students were randomly assigned to one of four groups to read an instructional passage displayed by microcomputer. Various macroprocessing options were available to students on the machine, and a posttest was administered after the passage.

Procedures

The experiment was conducted in two sessions. In the first, the following instruments were administered. 1) The Nelson-Denny Reading Test (Brown et al., 1981). 2) The Worry-Emotionality Scale (Morris, Davis, & Hutchings, 1981), with instructions for students to respond the way they felt at the moment. 3) Sarason's (1972) Test Anxiety Scale. 4) A multiple choice pretest assessing prior knowledge of the subject matter on which instruction was about to occur. Those students receiving pretest scores above 60% were excused from the second part of the investigation. 5) Some questions which required constructed responses about the student's habitual reading strategies.

In the second session, students were randomly assigned to one of four groups. 1) Adjunct Questions. In this group students received a total of 22 adjunct questions requiring constructed responses. Each question covered a preceding segment of text and was displayed after the text was erased. 2) Main review. This group was identical to the first, except that if students' answers to the adjunct questions were incorrect, they were so informed and required to

review the preceding screenful of text and respond to the question again. This procedure was repeated if the second answer was wrong. If students gave an incorrect answer the third time, a research assistant examined the response. If the answer was judged to be correct, students continued to read the succeeding text. If the response was wrong, they were required to perform one additional review. After the third reading, if the answer was still incorrect, the right response was supplied, and students continued reading. 3) Alternate Review. This group was identical to the preceding one, except the students were required to review on alternate, easier text. 4) Reading. In this group the text was presented without adjunct questions, although students were free to review alternate or main text or use any of the other options.

In each of the four groups students could use any of the following options. 1) Alternate Text. Students could consult an alternate, easier version of the text at the completion of any paragraph of the main text. Completion of the paragraph was signaled by sounding the computer's beep. 2) Notes. Students could take notes on the computer system. 3) Options Display. Students could consult a display describing each of the options. 4) Main Text Review. Students could review the main text, in addition to the required review, in two ways: a) whenever the backward arrow was pressed, the preceding sentence was displayed, and the present sentence deleted; b) students could request a range of sentences to be displayed by indicating the numbers of the beginning and ending sentences they wanted to review. 5) Alternate Text Review. Identical to the preceding option, except that the easier alternate text was reviewed. 6) Review of Notes. Students could review the notes previously taken.

It should be noted that the only time students could not review was when an adjunct question had been presented and a student response was expected. Once a response was made, review was permitted. The text material was displayed on Apple II Plus and IIe microcomputers. Delays in invoking any of the options or in proceeding from one segment to another never totaled more than 1 1/2 seconds.

All text in main, alternate, and explanatory passages was numbered and displayed one sentence at a time. When students completed a sentence and pressed the space bar, it was erased, and the succeeding sentence displayed. The number of the preceding sentence remained, and the space occupied by it was left vacant so that students could easily request reviews of preceding material.

The Worry-Emotionality Scale was administered two more times. The first was on computer, when students had completed half of the text passage, with instructions to respond the way they felt at that time. A second administration occurred immediately after the posttest, with instructions to respond the way they had felt during the test.

Materials

Prior to starting on the instructional text, a preliminary passage composed of 45 sentences was displayed. This material described the options and required that students use each option at least once. This material was designed to show students how to invoke each of the options.

The text passage and adjunct questions were developed for a prior study (Tobias,1984a). It introduced students to some general concepts about data processing and computer programming and illustrated these by a few instructions from the BASIC programming language. The passage was composed of 49 paragraphs. The main version consisted of 173 sentences, with 182 sentences in the alternate version. The main version was written in a 14th grade vocabulary (Fry ,1968); the alternate version used a 10th grade vocabulary and more regularly used an organizational scheme of super-ordinate introductory sentences followed by sub-ordinate sentences than did the main passage.

The pretests and posttests were also used in the prior study (Tobias, 1984a). The pretest was composed of a 50 item multiple choice test which had an alpha reliability of .75 in the prior investigation. This test was developed in a multiple choice format in order to obtain a fine-grained measure of prior knowledge. The posttest was composed of 51 fill-in items requiring constructed responses. Two subtests were developed from the posttest. The relevant section was composed of 25 items which were similar to the adjunct questions that were interspersed throughout the text. The incidental subtest contained 26 items whose content had not been covered by adjunct questions. The alpha reliability of the incidental subtest in the prior study was .85, compared to an alpha of .76 in the present investigation. The reliabilities of the relevant subtest in the present and prior investigations were .86 and .87, respectively.

Adjunct questions requiring constructed responses were created and inserted after every screenful of text. The questions were designed to require factual responses, recall of concepts, and applications of material taught. A variety of possible correct answers, determined in the prior investigation (Tobias 1984a), were scanned by the computer to score adjunct questions. The answer set included most possible correct responses, their semantic equivalents, and emphasized correctness of the concepts by tolerating a variety of misspellings. For example, one of the required responses was the word "multiply", and among the set of acceptable answers were any responses containing the letters "mltp".

Self-Reports of Processing

Students were administered two scales pertaining to their use of reading strategies. One scale asked students to describe, in a free response format, the type of reading strategies used in a variety of situations. This questionnaire was administered before students read

the passage (see Appendix 1). After completing the posttest, students filled out a second questionnaire in which they were required to check, on a Likert-type scale, a variety of strategies they might use while studying three subjects: Computer-science or mathematics, English, and Science. The strategies to be checked for each of these subjects included: re-read, prepare summaries, take notes, review, try to find an easier description, use a dictionary, answer study questions, plus an "other" category (see Appendix 2).

Subjects

A total of 140 students served as subjects for this experiment 100 female, 40 male. The sample was recruited from a an urban high school and was composed of 91 incoming members of the freshman class: 27 sophomores, 19 juniors, and 3 seniors. Students were required to obtain parental permission to volunteer for the research and were paid $7 for their participation.

Results

The major findings of this experiment dealt with three sets of data: Effects of the different treatments, individual difference measures, and their interactions on 1) learning, as determined by the posttest, and 2) on macroprocessing options used by subjects and their relationships to posttest scores. 3) The third data set dealt with the relationships between students' self-reports of reading strategies and options employed during this study.

Posttest Results

The means and standard deviations on the relevant and incidental posttest scores obtained by the four experimental groups are displayed in Table 1.

Insert Table 1

In addition, Table 1 also shows the means and standard deviations of the different groups on the pretest, the Nelson-Denny Reading Test, and the test anxiety data.

The effects of the independent variables on the incidental and relevant posttest were analyzed by multivariate multiple regression analysis using the MANOVA program in the SPSSx Package (SPSSx,1983). In order to reduce the effects of co-linearity, scores on continuous variables, such as pretest and test anxiety, were converted to average deviations, as recommended by Cronbach and Snow (1977). The results of that analysis and the univariate results for both incidental and relevant posttest are displayed in Table 2. (See Appendix 3 for the regression coefficients for these effects).

Insert Table 2

There were significant multivariate differences on posttest among the treatment groups. Univariate analyses indicated that this effect was largely attributable to differences on the relevant part of the posttest. The means, displayed in Table 1, indicated that the required review groups had significantly higher scores than both the optional review group and the group reading the text without adjunct questions. Pretest exerted a significant effect on posttest. Students with higher pretest scores out-performed lower scoring students. There was also a significant interaction among treatment, pretest, and worry on relevant posttest scores. The regression surfaces for three treatment groups were similar, except for the group required to review the alternate text. In that group, as students pretest score increased and worry decreased, scores on the relevant posttest increased sharply.

Macroprocessing Options

The number of times students in the different groups used the various macroprocessing options is shown in Table 3, which also

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Insert Table 3
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displays the correlation of each macroprocessing option with total posttest score.

The effects of treatment, pretest, anxiety, and their interactions on the macroprocessing options were determined by computing a multivariate multiple regression analysis. The results of that analysis and of the univariate analyses on each of the dependent variables are displayed on Table 4.

Insert Table 4

The results indicated that there was a significant multivariate effect for treatment on all of the dependent variables and that there were significant interactions among both treatment and pretest scores, as well as worry and treatment. (See Appendix 4 for the regression coefficients for all effects in this analysis.)

There were highly significant univariate effects for both the number of main and the number of alternate sentences reviewed. Table 3 indicates that the group required to review the main text reviewed 5 to 30 times more sentences, compared to any of the other groups. Furthermore, the alternate review group reviewed about 20 times more alternate sentences than any of the other groups. There were no significant univariate differences for any of the other macroprocessing options, indicating that the multivariate effect was

largely attributable to reviews of main and alternate texts. The univariate results indicated that students with higher pretest scores reviewed significantly fewer alternate sentences than low scoring students, and worried subjects reviewed more alternate sentences than their less worried peers.

The univariate analyses also indicated a number significant interactions. These are displayed in Figures 1-3.

Insert Figures 1-3 here

Relationship Between Option Use and Strategies

A content analysis of students' answers to the free response scale asking about their reading strategies was conducted, and answers were clustered into categories. A multivariate analysis of variance was then computed in which the independent variables were the response categories, and the dependent variable consisted of the number of sentences on which options were actually used in this experiment.

The first question, the categories of student answers to the question, and the number of students per category are shown in Table 5.

Insert Table 5

The multivariate analysis of variance yielded a Wilk's lambda of .85 for this analysis, which was not significant. The univariate results indicated that none of the differences among the groups on any of the macroprocessing options was significant.

The second question and the number of students giving different categories of answers to the question are displayed in Table 6.

Insert Table 6

The significance of differences in actual use of macroprocessing options among the groups shown in Table 6 were examined by multivariate analysis of variance; Wilk's lambda was .80, which was also not significant. In the univariate analyses, the only significant difference among the groups was on the frequency with which the options menu was inspected. This comparison indicated that students reporting that they mark or underline text used the options menu more frequently than any other group.

The third question and the number of students in each of the response categories are displayed in Table 7.

Insert Table 7

The multivariate analysis of variance for differences among these groups on strategies actually used yielded a Wilk's lambda of .88, which was not significant. Again, univariate analyses for the various strategies were not significant, with the exception of the frequency with which the options menu was consulted. The group which indicated that they would use a variety of study techniques inspected the options menu more frequently than any of the other groups.

The fourth question asked: "When you are reading and find a word that you don't understand which of these do you do ? You may check more than one". The choices offered included: A. Try to figure it out from the sentence. B. Ask someone for help. C.Look at a dictionary. D. Skip it and continue reading. E. Other. Please specify. Since students could pick more than one choice in answer to this question, responses were also grouped into categories which are displayed in Table 8.

Insert Table 8

The multivariate analysis of variance for differences among these groups resulted in a nonsignificant Wilk's lambda of .92. The univariate analyses of differences among the groups on each of the options indicated that there were no significant differences on any of these options.

Student responses on the Likert-type scales regarding the reading strategies they would use in various areas, administered in the first session of the study, were then correlated with utilization of similar strategies in this study. Two analyses were computed. In the first, the responses to all questions in each area were added. That is, students' overall responses in computer-science or mathematics, English, and science were added to yield a total score, and these three scores were then correlated with option use in this experiment. This analysis identified only one significant correlation of -.20 between the total score reflecting all the strategies used in English and frequency with which students took notes. None of the other correlations were significant.

Relationships were also examined between student self-reports of strategy use and employment of similar options in this study. For example, students were asked to note how frequently they took notes, how frequently they tried to find an easier description, and how frequently they re-read or reviewed. Responses to each of these questions were then correlated with note taking, use of alternate text, and reviews in this study. None of these correlations was significant.

Discussion

The findings of this study indicated that students who were required to review preceding text when their answers to adjunct questions were incorrect obtained significantly higher scores on that portion of the posttest related to the adjunct questions. Pretest score contributed significantly to overall posttests scores, and there were significant interactions among experimental conditions, pretest, and test anxiety. There were highly significant differences among the groups in option use, principally on the number of sentences reviewed, in addition to a number of significant interactions for these data. Finally, there was little relationship between students' self-reports of reading strategies and option use. These results will be discussed below, and their implications for further research suggested.

Macroprocessing and Achievement

The higher achievement of those required to review had been predicted. In these conditions, students had to re-read preceding main or alternate text if they answered an adjunct question incorrectly. It seemed clear that these groups did not learn more about the text in general, since there were no differences on that part of the posttest which was unrelated to adjunct questions. Apparently, students required to review skimmed preceding text for content relevant to the adjunct questions rather than carefully re-reading all of the material on the prior screenful. Those not required to re-read, that is, optional review and read-only groups, had higher (though not significantly so) scores on the incidental portion of the posttest. This finding strengthened the interpretation that while reviewing, students attended mainly to portions of the posttest which were relevant to the adjunct questions, otherwise their scores on the incidental posttest would have increased as well.

The interaction among treatment and pretest on the number of sentences of alternate text read (see Figure 4) is of some interest. It should be noted that these data describe the number of sentences in alternate text that were consulted while reading the main passage, irrespective of reviews. The interaction suggested that as pretest score increased, the number of alternate sentences read by both mandatory review groups increased. On the other hand, the number of alternate sentences read decreased as pretest score increased for the optional review and read-only groups. It seemed that more knowledgeable students, determined by higher pretest score, developed the following preventative strategy: They read the easier text when comprehension difficulty occurred in order to ensure that they would be able to answer the ensuing adjunct question correctly and avoid a required review.

The interaction among pretest and treatment on number of main text sentences reviewed (see Figure 2) indicated that in the group required to re-read main text, students with high pretest scores

reviewed slightly fewer sentences than those with lower pretest scores. For all other groups the number of sentences reviewed increased as pretest score went up. Apparently, more knowledgeable students made fewer errors on the adjunct questions and hence had to review fewer main text sentences than those with less prior knowledge. Especially remarkable (see Figure 2) were the large differences between the groups. It will be noted that those required to review main text re-inspected a mean of 100 sentences, whereas all of other groups reviewed less than 20.

The two interactions involving anxiety indicated that as worry (a component of test anxiety) increased, the number of sentences students had to review also went up. These findings were in accord with much other research relating anxiety to errors (Sarason, 1980) and indicated that more anxious individuals made more mistakes on adjunct questions and therefore were required to review more sentences. For the groups who did not have to review main text, the interaction function had an essentially flat slope. It seemed that anxious students in these groups did not voluntarily review main text more often, as had been expected from prior research (Tobias, in press). Presumably, these results are attributable to problems with students' use of reading strategies, to be discussed below.

The results indicated that there were significant overall differences among the groups in the frequency with which macroprocessing options were used. This finding was a function of differences in the number of main or alternate sentences students were required to review. Univariate results indicated that none of the differences among groups in their use of other options approached significance. Apparently, being required to review was the only factor inducing students to use the macroprocessing options differentially.

Correlations between number of sentences re-examined and posttest scores were -.55 for those required to review main text and -.62 for the alternate review group, both significant beyond the .01 level. These correlations suggested that students who made errors on the adjunct questions and were forced to review earned lower posttest scores than those with fewer mistakes, who reviewed less often. Since the required review groups outperformed the others on the relevant portion of the posttest, it can be inferred that if students who had difficulty with the text did not have to review, their scores on the posttest may well have been even lower. This interpretation is strengthened by the correlations between the number of reviews and pretest scores for groups required to re-read: -.43 ($p < .01$) for those required to re-read alternate text and -.27 for the main text review group. Knowledgeable students were required to review less frequently than those with less familiarity with the subject, and they achieved higher posttest scores, as can be seen from the correlation of .55 ($p \leq .001$) between pretest and posttest for all groups combined.

Option Use: Self-Report and Actual

There was little relationship between student self-report of reading strategies and use of similar macroprocessing options in this study. These results conflict with those reported by Alexander et al. (1984), who found that students who reported using strategies did so. The differences in the results of these studies could be attributed to the way strategy use was determined. In this experiment option use data were recorded by computer, generating a precise and relatively fine-grained measure specifying the number of sentences involved in option use. Alexander et al.'s data were obtained by observing the behavior of readers and were recorded in terms of total number of "lookbacks" or reviews.

It has been noted that students read the text selection on microcomputers. Some aspects of this situation were different from students' usual reading. That is, material was exposed one sentence at a time, sentences were deleted when students signaled that they had finished them, whereupon the succeeding sentence was displayed. It is possible that this presentation and the use of cathode ray tube screens for text display made the situation somewhat more artificial than the usual reading tasks encountered by students. The absence of relationships between student reports of strategy use and actual use may possibly be attributed to these factors. Since both self-report measures of strategy use employed in this study were not specific to the computer administered reading task, it remains for further research to clarify this possibility.

A further reason for inconsistent and ineffective use of strategies may be that students may not know how to use strategies to improve their learning. Since students are rarely instructed in the use of cognitive strategies to help them learn more effectively, they probably use those processes that they think are useful. Unfortunately, such thinking may often be based on faulty or vague information, such as test outcomes. Students' test scores may be a function of variables other than processes used, including the time spent studying, their prior knowledge of the subject, and the quality of instruction, among other possibilities. Furthermore, reports of test results are rarely specific enough to give useful feedback regarding areas mastered by students, and content on which further work is required. It is difficult to relate test outcomes to strategy use in the absence of such diagnostic information. Finally, feedback regarding examination results is generally given many days after studying, adding further difficulties to students' attempts to determine which strategies were most useful.

In the absence of either instruction or adequate information regarding effective strategies, one can assume that students' use of cognitive strategies is similar to "superstitious" behavior ( ), in which chance reinforcement coincides with some actions, leading to their repetition. The low correlations between number of reviews and posttest scores for the groups not required to re-read (.18 for optional review and -.18 for the reading group) strengthen this possibility. Similarly, taking notes had a correlation of .05 with posttest for all groups combined. These correlations suggested that

voluntary option use was ineffective in improving learning.

Whatever the reasons for these results, there was little relationship between student reports and option use in this study. As mentioned above, in a prior study (Tobias, 1984a) student use of reading strategies was found to be extremely variable and ineffective. If students do not have a clear idea of how intensively they use various strategies in this situation, then it is not surprising that strategy use was unrelated to outcomes or to various student characteristics.

General Discussion

Some of the results in both the present and prior investigation were paradoxical. A good deal of evidence indicated that strategies are used variably and ineffectively. In this study, even though required review did improve learning, the fact that students in these conditions reread approximately 10 to 20 times more sentences than others indicated that this was hardly an efficient process. On the other hand, there was also evidence of strategic behavior. For example, Figure 4 indicates that knowledgeable students in required review groups apparently developed a preventative strategy. They more frequently inspected the easier, alternate text prior to answering adjunct question than those with lower pretest scores. This strategy made it less likely that students might give wrong answers to the adjunct questions and be required to review. Similar strategic behavior was suggested by the triple interaction on relevant posttest and by the evidence of skimming for the right answer.

The paradox between variable and ineffective behavior on the one hand and relatively strategic behavior on the other may be explained by the ambiguity and vagueness regarding what understanding means to students. One can hypothesize that it is difficult for students to determine when they have mastery of a passage because the internal representation of a new subject may be relatively undifferentiated. That is, students may not have a specific strategy to determine whether they understand a passage, especially when the subject matter is new to them. However, when a clear-cut goal is available, such as being required to review in order to answer a question or avoiding such a review by reading the alternate passage, strategic behavior quickly becomes evident. In the absence of such a clear goal, variable and ineffective use of strategies appears to occur.

These results suggest a hypothesis. When students are given an explicit criterion against which to assess their comprehension, reading will become more strategic, compared to a condition in which criteria are more ambiguous. Strategic reading should, in turn, be accompanied by improved comprehension. We expect to test this hypothesis by varying the explicitness of the comprehension criteria available to students. It can further be predicted from ATI research (Tobias, 1982) that the more explicit the criterion, the better the performance of students with limited prior knowledge and poor reading skills. Knowledgeable students, or good readers are not expected to profit as much from explicit criteria since they are likely to use

their own implicit criteria. Furthermore, with explicit criteria review will generally be more efficient, that is, a smaller number of sentences will be re-read, than in the absence of such criteria.

The results were equivocal regarding the interaction between prior knowledge and use of options. It had been expected that knowledgeable students would use less instructional support than students less familiar with the content. While this pattern was seen in some of the interactionss, it was not the case in others. These data suggest that there is considerable inconsistency in the use of instructional support, and further research is required to clarify the characteristics of options that can be expected to be used more heavily by those with limited prior knowledge to improve their preformance. Clearly, the results suggest that the mere presence of different forms of instructional support does not guarantee that less knowledgeable students will use them frequently.

The findings from metacognitive training studies (Palinscar & Brown, 1984; Stevens, 1983) suggested that less able students must be taught to use strategies in order to use them effectively. These findings imply that if students with limited prior experience with a subject use instructional support ineffectively, they may need to be taught to use available assistance to improve their learning, whereas knowledgeable students apparently are able to use such support without special instruction. The hypothesis (Tobias, 1982) predicting that less knowledgable students will profit more from instructional support than those who mare more familiar with a subject will, then have to account for students' ability to use available forms of assistance. The predicted relationship may be expected to apply only when students can use the support effectively, or when they are prompted or taught to use the assistance.

Worry, a component of test anxiety, was positively related to number of reviews for all groups, confirming similar findings in prior research (Tobias, 1984b). That result appeared largely attributable to the groups required to review, since the interactions did not give any evidence of such relationships for the conditions in which review was optional. These results may be caused by the problems, described above, in students' use of review and other strategies. When students have clear criteria against which to assess their comprehension and are aware that review can improve their comprehension, it is expected that more anxious students will review more often and profit more from such reviews than their less anxious counterparts.

Table 3.1 Means and Standard Deviations of Selected Dependent and Independent Variables

		Main Review (M=25, F=10)	Alternate Review (M=29, F=6)	Optional Review (M=25, F=12)	Read Only (M=21, F=12)
Achievement Variables					
Posttest Relevant Score	Mean	14.2	13.12	11.6	10.35
	SD	4.78	5.97	5.43	5.3
Posttest Incidental Score	Mean	8.1	7.7	9.0	9.0
	SD	3.9	4.39	4.1	3.7
Posttest Total Score	Mean	22.3	20.8	20.6	19.3
	SD	8.26	9.94	9.10	8.7
Reading and Pretest Scores *					
Pretest Total Score	Mean	19.51	17.82	19.1	19.8
	SD	4.85	5.23	4.9	5.5
Nelson Denny Reading	Mean	34.03	34.45	35.83	35.1
	SD	11.03	14.85	11.95	11.7
Nelson Denny Comprehension	Mean	33.25	30.97	34.97	33.8
	SD	11.3	18.51	10.10	10.3
Nelson Denny Total	Mean	67.28	65.42	70.8	68.9
	SD	20.37	25.36	20.72	19.7
Anxiety Measures					
Test Anxiety Scale	Mean	19.45	18.08	17.81	17.6
	SD	5.30	7.57	5.55	5.4
Worry scale before reading	Mean	8.9	8.17	8.1	7.39
	SD	3.8	3.92	3.4	3.5
Worry scale during reading	Mean	8.6	9.37	9.7	7.96
	SD	3.2	4.6	4.8	3.2
Worry scale after reading	Mean	9.6	9.25	10.0	9.7
	SD	3.9	4.8	4.9	4.4

* Raw Score

TABLE 3.2 Multivariate and Univariate Results of Posttest.

Independent Variables	Wilks Lambda	Univariate Results POSTTEST Incidental	Relevant
Treatment (TRT)	8.95**	1.29	4.84**
Pretest (Pre)	32.14**	55.04**	57.56**
WPOST	1.81	3.86	3.42
PRE X WPOST	<1	<1	<1
TRT X WPOST	<1	<1	<1
TRT * PRE	<1	<1	<1
PRE X WPOST X TRT	1.94	2.49	3.15*

** p. <.01

* p. <.05

Table 3.3 Means, Standard Deviations and Correlations with Posttest for Option Use Data.

		Main Review	Alternate Review	Optional Review	Read Only
Option Use Data					
Main Text Reviews[1]					
	M	100.51	3.05	12.32	17.57
	SD	39.76	3.80	15.46	16.39
	r	-.55**	.26	.18	.22
Alternate Text Reviews[1]					
	M	3.12	122.61	5.47	4.98
	SD	8.78	51.54	10.54	7.85
	r	.08	-.62**	.22	-.18
Inspection of Alternate Text[1]					
	M	28.51	27.21	19.48	22.68
	SD	48.80	44.13	35.88	36.35
	r	.32	.26	.14	-.27
Notes					
	M	5.68	7.02	7.35	8.48
	SD	10.72	8.45	11.27	9.32
	r	.10	.04	.11	.02
Review of Notes					
	M	.39	.76	.73	1.35
	SD	1.41	1.74	1.72	1.87
	r	.05	0.00	-.08	-.06
Options Menu					
	M	1.55	.97	1.10	1.84
	SD	2.08	1.93	2.01	2.73
	r	-.04	-.05	.28	-.06

[1] Number of sentences.

** $p. < .01$

Table 3-4 Multivariate and Univariate Analyses of Variance of Option Utilization Data.

		Options					
	Wilks Lambda	Main Text Reviews	Alternate Text Reviews	No. of Sentences Alternate Text	Notes	Review of Notes	Options Menu
Independent Variables							
Treatment (T)	43.24**	143.38**	220.79**	<1	<1	1.96	1.19
Pretest (Pre)	1.83	<1	7.85**	<1	1.14	1.53	2.45
Worry (W)	2.08	<1	8.24**	2.45	<1	<1	<1
T * Pre	2.32**	3.34*	1.18	3.81*	<1	<1	2.34
T * W	2.77**	2.88*	10.26**	<1	<1	2.08	<1
Pre * W	1.68	<1	<1	<1	1.24	6.35**	5.02*
Trt * Pre * W	<1	<1	1.29	<1	<1	1.17	<1

** $p. < .01$
* $p. < .05$

Table 3.5 Responses to question: "What do you do when you are confused about what you are reading?"

Category	n	%
Reread	55	41
Ask for help or do nothing	25	19
Figure out meaning	31	23
Ask for help or reread	22	16
Missing data	7	

Table 3.6 Responses to question: "When there is something you want to remember while reading, what do you do?"

Category	n	%
Reread, rephrase, or repeat to themselves	21	15
Write it down or take notes	49	36
Mark down or underline	10	7
Miscellaneous	24	17
Taking notes with other options	32	23

Table 3.7 Responses to question: "While reading, what do you do when come across something that you think will be on a test?"

Category	n	%
Reread	9	7
Write down or take notes	40	31
Various techniques	39	30
Write down and use various techniques	40	31

Table 3.8 Responses to question: "When you are reading and find a word that you don't understand which of these do you do?"

Category	n	%
Try to figure out with various techniques	50	58
Seek help or actively solve problem	67	77
Miscellaneous	19	22

Legend of Figures

Figure 3.1 Interaction among treatment and pretest on main text review.

Figure 3.2 Interaction among worry and treatment on main text review.

Figure 3.3 Interaction among worry and treatment on alternate text review.

Figure 3.4 Interaction among pretest and treatment on alternate text use.

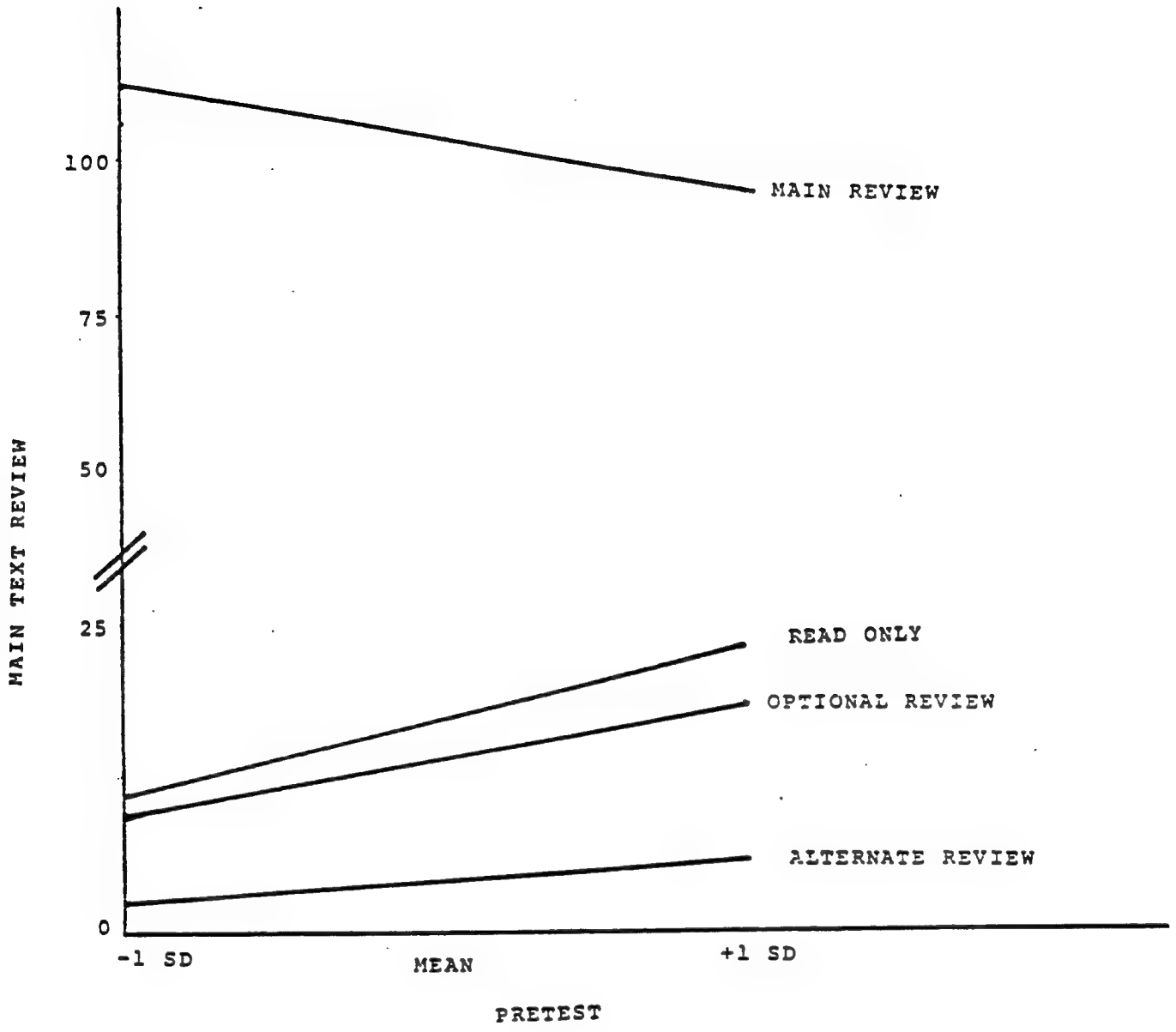
100
75
50
25
0
MAIN TEXT REVIEW
MAIN REVIEW
READ ONLY
OPTIONAL REVIEW
ALTERNATE REVIEW
-1 SD
MEAN
+1 SD
PRETEST

FIGURE 3.1

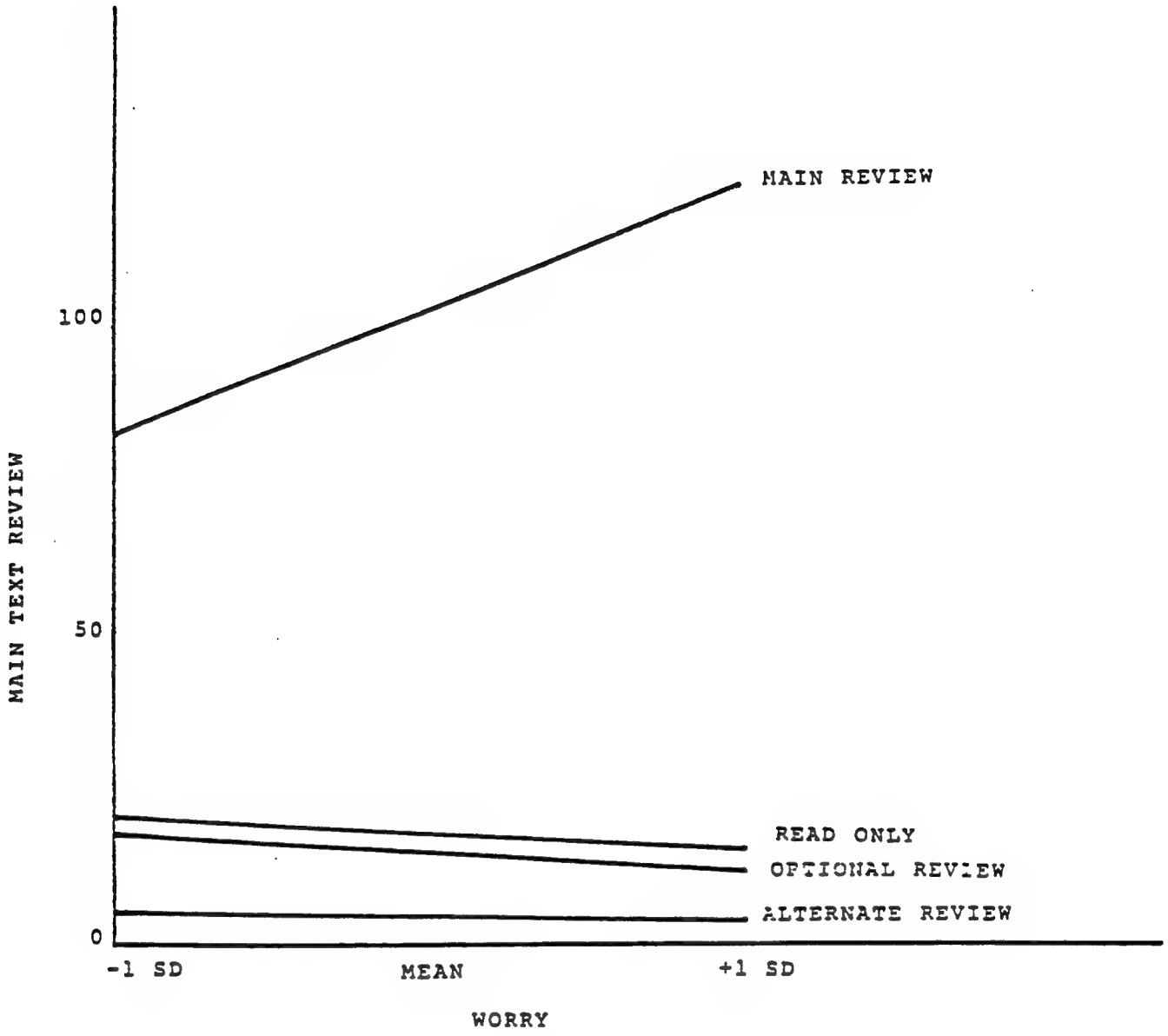
MAIN REVIEW
100
MAIN TEXT REVIEW
50
READ ONLY
OPTIONAL REVIEW
ALTERNATE REVIEW
0
-1 SD
MEAN
+1 SD
WORRY

FIGURE 3.2

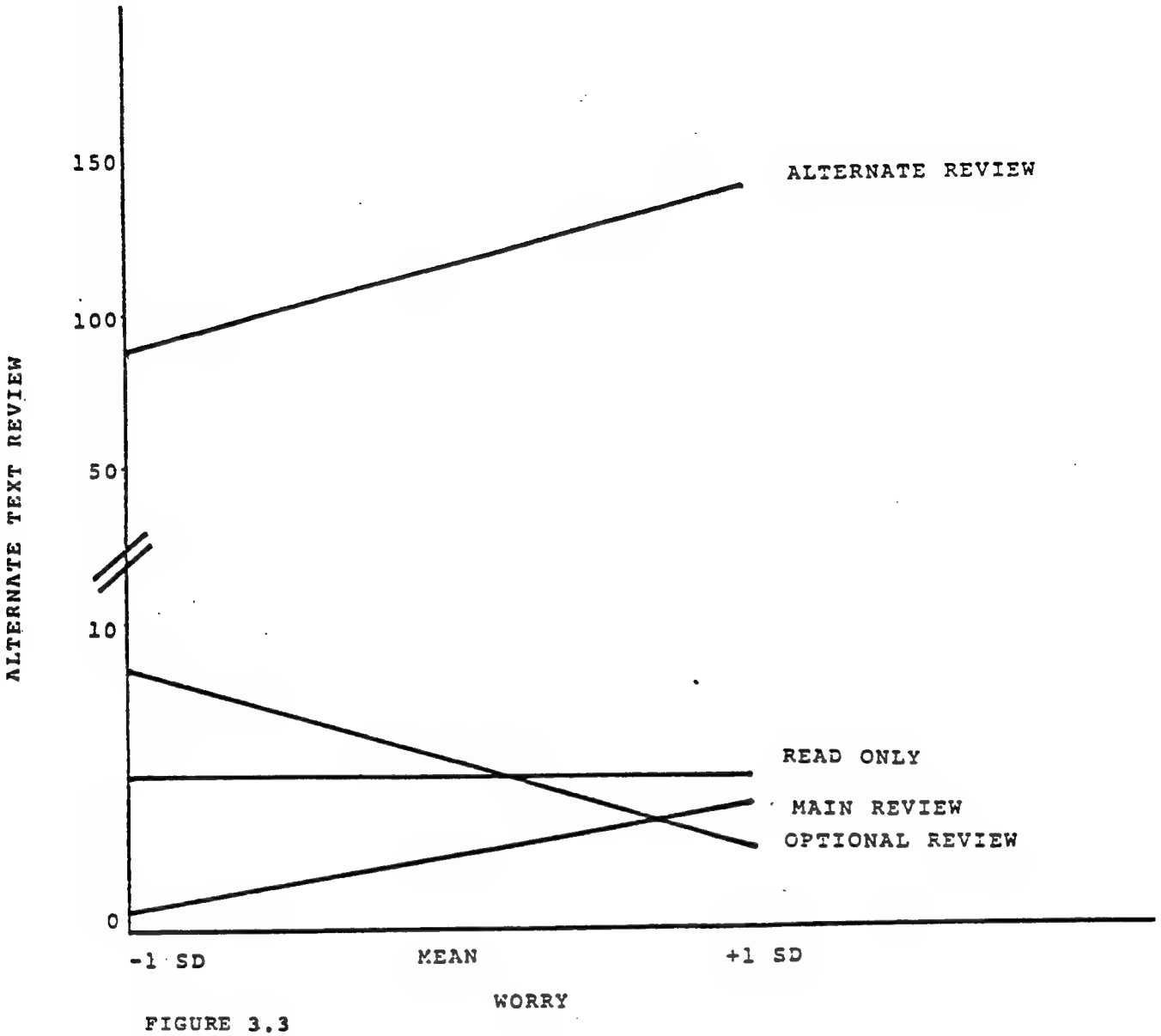
ALTERNATE TEXT REVIEW
150
100
50
10
0
ALTERNATE REVIEW
READ ONLY
MAIN REVIEW
OPTIONAL REVIEW
-1 SD
MEAN
+1 SD
WORRY

FIGURE 3.3

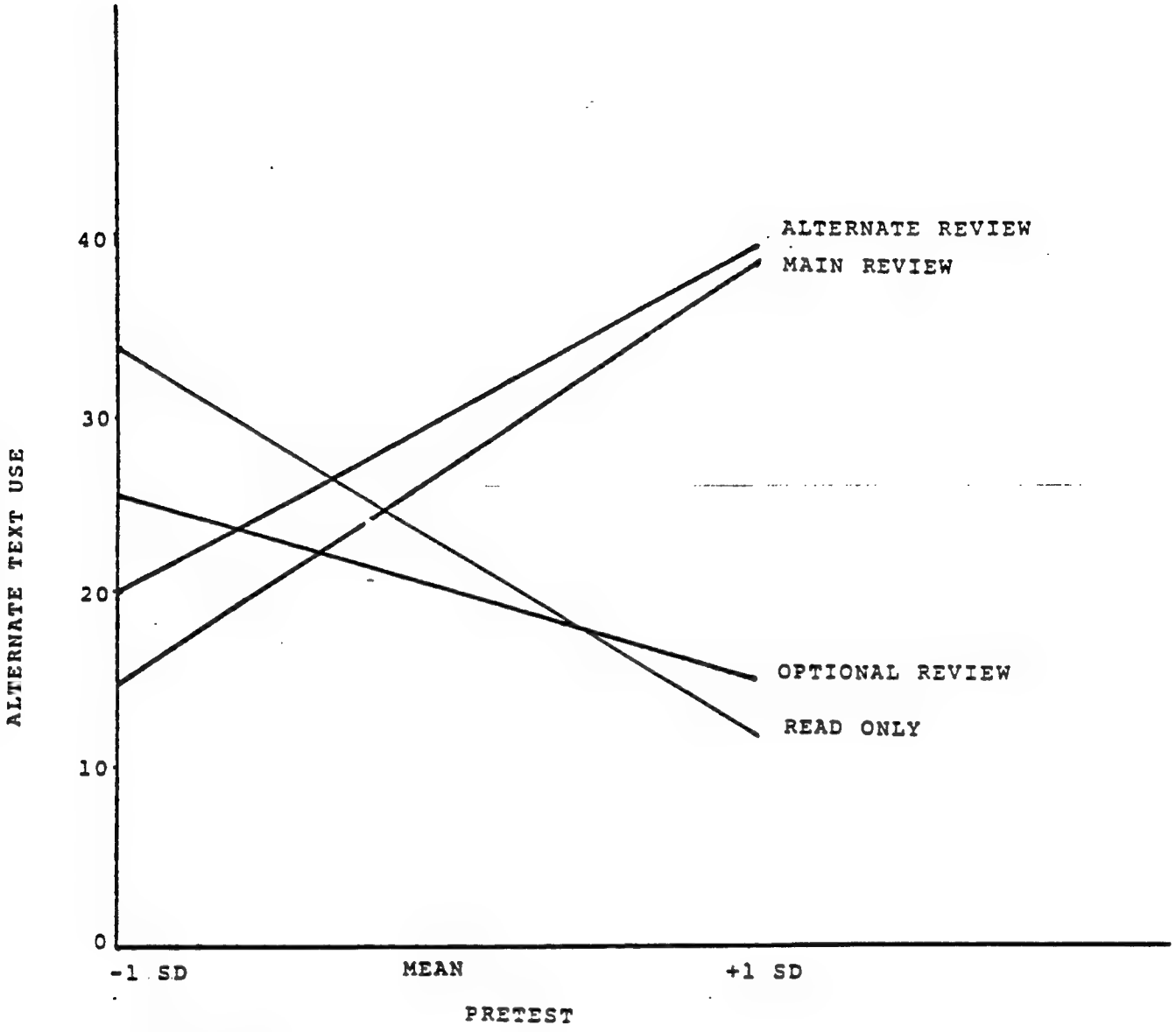
ALTERNATE REVIEW
MAIN REVIEW
OPTIONAL REVIEW
READ ONLY
ALTERNATE TEXT USE
40
30
20
10
0
-1 SD
MEAN
+1 SD
PRETEST

FIGURE 3.4

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Appendix 3.1

Reading Habits Scale

1. What do you do when you are confused about what you are reading? (Turn over if you need more space)

_____

_____

_____

2. When there is something you want to remember while reading, what do you do? (Turn over if you need more space)

_____

_____

_____

3. While reading, what do you do when you come across something that you think will be on a test? (Turn over if you need more space)

_____

_____

_____

Check your answer in the spaces provided.

4. When you are reading and find a word that you don't understand which of these do you do? You may check more than one.

_____ a) Try to figure it out from the sentence.

_____ b) Ask somebody for help.

_____ c) Look at a dictionary.

_____ d) Skip it and continue reading.

_____ e) Other Please specify. _____

_____

5. How often do you reread a sentence you have read before

_____ a) Very often.

_____ b) Often.

_____ c) Sometimes.

_____ d) Rarely.

6. Compared to other students how often do you take notes

_____ a) Very often.

_____ b) Often.

_____ c) Sometimes.

_____ d) Rarely.

7. Please rate your reading ability:

_____ a) Excellent.

_____ b) Very Good.

_____ c) Average.

_____ d) Below average.

_____ e) Poor.

Appendix 3.2

Attitude Survey

ID# _____ Name _____

Please pick the choice that best describes your feelings in the space provided.

_____ Think of the material you have just completed. Please estimate how much of it you have mastered.

1. 1/4.
2. 1/2.
3. 3/4.
4. all of it.

_____ How did you feel about the way the material was presented?

1. Enjoyed Presentation.
2. Presentation moderately pleasant.
3. Presentation unpleasant.
4. Disliked presentation.

_____ Did you find yourself trying to get through the material, rather than trying to learn?

1. All of the time.
2. Most of the time.
3. Some of the time.
4. Never.

_____ Would you like to learn other material in a similar format?

1. Definitely.
2. Probably.
3. Probably not.
4. Definitely not.

_____ Would you prefer reading the same material in a textbook?

1. Definitely.
2. Probably.
3. Probably not.
4. Definitely not.

_____ How did you feel about the options provided on the computer?

1. Very helpful.
2. Helpful.
3. Somewhat helpful.
4. Not too helpful.

_____ On a test of what you have just read what grade would you expect?

1. A 2. B 3. C 4. D 5. F

_____ Once you got used to them, the options were:

1. very easy to use.
2. easy to use.
3. difficult to use.
4. very difficult to use.

_____ Were there other options you would have liked to have? Please list them below.

_____

_____

_____

_____

_____

Below are a number of strategies used by students while reading. Please indicate how often you use each of these strategies in different subjects, such as in computer science or math, English literature or in science.

In computer science or mathematics how often would you do any of the following? (Please check the appropriate box)

	All of the Time	Most of the Time	Some of the Time	Never
Reread				
Prepare Summaries				
Take notes				
Review				
Try to find an easier description				
Use a dictionary				
Answer study questions				

Other (Please describe) _____

_____

When reading for English classes how often would do any of the following? (Please check the appropriate box)

	All of the Time	Most of the Time	Some of the Time	Never
Reread				
Prepare summaries				
Take Notes				
Review				
Try to find an easier description				
Use a Dictionary				
Answer study questions				

Other (Please describe) _____

In science, how often would you do any of the following? (Please check appropriate box)

	All of the Time	Most of the Time	Some of the Time	Never
Reread				
Prepare summaries				
Take notes				
Review				
Try to find an easier description				
Use a dictionary				
Answer study questions.				
Other (Please describe)				

Table A3.3 Regression coefficients for Relevant and Incidental Posttest.

	Posttest Relevant	Posttest Incidental
Main Review (T1)	2.28	1.11
Alternate Review (T2)	1.12	-1.53
Read Only (T3)	-1.59	- .16
Pretest (Pre)	.568	.388
Worry (W)	-.207	-.160
Pre X T1	-.23	-.068
Pre X T2	.154	.108
Pre X T3	-.023	.049
Pre X W	.023	.008
W X T1	.027	.037
W X T2	.024	-.033
W X T3	.016	.094
Pre X W X T1	.014	-.005
Pre X W X T2	-.119	-.068
Pre X W X T3	.024	.042
Constant	11.85	9.15

		Mean	SD
Transformed Means and Standard Deviations:	Pretest	-.04	5.1
	Worry	.03	4.54

Table A3.4 Regression coefficients of all experimental effects on macroprocessing options.

	Main Text Reviews	Alternate Text Reviews	No. of Sentences Alternate Review	Notes	Review of Notes	Options Menu
Main Review (T1)	89.81	-2.93	4.34	-2.51	-.49	.408
Alternate Review (T2)	-9.59	117.47	8.24	-1.73	-.33	-.469
Read Only (T3)	3.09	-1.60	-.58	.68	.47	.743
Pretest (Pre)	.33	-.19	-1.33	.003	-.009	.19
Worry (W)	-.85	-.57	-1.71	-.176	-.088	-.003
Pre X T1	-2.47	.54	3.49	.59	.048	-.178
Pre X T2	-.07	-1.86	5.23	.29	.100	-.279
Pre X T3	.65	-.23	-1.32	.02	.066	-.07
Pre X W	-.042	.012	.096	.04	.003	-.008
W X T1	3.87	.966	-2.65	- .08	-.028	-.156
W X T2	.99	6.54	3.74	.38	.152	-.07
W X T3	.58	.44	-.83	.85	.203	.099
Pre X W X T1	.164	-.03	-.43	-.134	-.027	-.039
Pre X W X T2	.03	.40	-.19	-.136	-.028	-.013
Pre X W X T3	-.097	-.17	-.37	-.185	-.030	-.001
Constant	12.75	6.01	21.48	7.76	.82	1.05

		Mean	SD
Transformed Means and Standard Deviations:	Pretest	.004	5.12
	Worry	.007	4.09

Chapter 4: Experiment III.

REVIEW, TEST ANXIETY, AND PRIOR ACHIEVEMENT

Sigmund Tobias
Joanne Sacks

Abstract

This study examined the use of macroprocesses, such as review in comprehension and their relationship as well as interaction with test anxiety, and prior achievement. A total of 122 students were randomly assigned to read a text passage displayed on microcomputers and either given choice of, or required to review when their answers to adjunct questions were incorrect. Students were also assigned to one of these review modes: 1) Simple review. 2) Review while thinking of the prior question. 3) Review with question visible. There were no differences on posttest scores, number of sentences reviewed, or use of other strategies attributable to choice, or review mode. These results were compared to prior findings, and discussed in terms of the apparent effectiveness of prompting students to use review to improve achievement. A number of interactions on posttest were discussed in terms of the effects of prior knowledge and anxiety.

A good deal of research has been devoted to clarifying the cognitive processes involved in reading. A content analysis of the Journal of Educational Psychology (Tobias, 1985a) has indicated that the most frequently published category of articles in the 1984 volume dealt with cognitive processes in comprehension. Less attention, however, has been directed to clarifying the relationships and/or interactions of such processes with a variety of individual difference variables. The major purpose of this study was to continue a research program studying the latter question.

Strategic Reading

There are a number of reports, summarized in detail elsewhere (Tobias, 1985b), indicating that students' reading is remarkably unstrategic. For example, there is evidence (Baker & Anderson, 1982; Garner & Kraus, 1981-1982) that the majority of secondary school and college students do not detect inconsistencies in text. Similarly, in studies (Alexander, Hare & Garner, 1984) of the frequency with which students looked back to prior reading to answer questions infrequent use of lookbacks has been reported.

In order to precisely monitor student's cognitive processing of instruction, or macroprocessing (Tobias, 1982), and to study the interaction between macroprocesses and student characteristics several investigations (Everson & Tobias, 1985; Tobias, 1985b) used a computer based reading task. A passage written in a 14th grade vocabulary (Frye, 1968) was employed. Students were free to use a variety of macroprocessing options including the following: 1) They

could consult an alternate, easier text written in a 10th grade vocabulary and regularly following a superordinate lead sentence-subordinate succeeding sentence format. 2) Students could take notes on the computer system. They could 3) review main text, 4) alternate text, and 5) their notes, or 6) consult a display describing all the options and indicating how they could be invoked.

Everson and Tobias (1985) used this task to compare three conditions: answering adjunct questions and receiving feedback regarding response accuracy, an adjunct question group, and a group without questions. Those assigned to adjunct questions outperformed the read-only group on posttest, confirming many other findings (Anderson & Biddle, 1975; Hamilton, in press). More interestingly, these college students' use of the macroprocessing options was found to be extremely variable, ineffective, and largely unrelated to posttest, reading ability, anxiety, or prior knowledge of the subject.

A succeeding study (Tobias, 1985b) examined whether required, compared to optional review led to more effective use of macroprocesses and higher achievement. Two groups were required to review preceding main or alternate text when their answers to adjunct questions were incorrect. In addition, an adjunct question and a read-only group were used. Those required to review out-performed the other two groups. Also, as expected the required review groups re-read the text much more frequently than those in other groups or than subjects in the first investigation. Finally, the variability of option use was decreased substantially.

The second study (Tobias, 1985b) also found evidence of reasonably strategic student behavior in some situations and for some

students. For example, required review improved only the learning of adjunct question relevant material, suggesting that students used review strategically to skim for question relevant content. Also, students with high prior content knowledge consulted the alternate, easier text more frequently than those less knowledgeable. Such students apparently developed a strategy of using the easier text to avoid being required to review, as they would have had to if they gave a wrong response to adjunct questions.

Giving students feedback regarding the correctness of their answers to adjunct questions did not improve learning, compared to a group than merely answering questions (Everson & Tobias, 1985), nor did it lead to more effective use of macroprocesses. On the other hand, requiring review when answers to adjunct questions were incorrect (Tobias, 1985b) did improve achievement and reduced the variability of macroprocessing option use. Other than in the required review conditions, students had access to review and other options in both prior studies. Students could, therefore, review prior text when feedback indicated that their answers were incorrect, though review was not suggested. In the present study we examined the effects of connecting feedback with review. Students were not merely given, feedback about the correctness of their responses to adjunct questions but they were also asked, in the optional review conditions, if they would like to review to correct their answers; review was mandatory in the required condition.

Prior research (Tobias, 1985b) also suggested that strategic reading occurred when students had clear guidelines to evaluate what was expected of them. However, when students had to determine whether they comprehended novel material, few criteria were available

to help them make these decisions, leading to variable and ineffective use of strategies. It was reasoned that evaluation of comprehension might be facilitated in one of two ways: 1) if students were knowledgeable about the subject matter they could more easily assess their grasp of the content than if the subject was novel to them, or 2) in the absence of such knowledge, if external criteria were provided to which comprehension of the content could be compared. In this study all students were given feedback when their adjunct question responses were wrong. Assistance in evaluating comprehension was implemented by either permitting, or requiring some groups to review with the preceding question visible, or by suggesting that they think of the preceding question.

It was expected that displaying adjunct questions while re-reading would lead to superior achievement compared to simple review, and that asking students to think of the answer would be in an intermediate position. ATI research (Tobias, 1982; 1985b; in press) led to predictions of interactions between prior knowledge and both review mode, and the choice variable. That is, high support for review should be especially beneficial for students with low prior content knowledge whose internal representation of the subject matter was likely to be relatively undifferentiated. Similarly, required review was expected to be more advantageous for students with little prior experience with the content, compared to those who were more knowledgeable.

Anxiety, Learning and Review

It has frequently been documented (Sieber, O'Neill, & Tobias, 1977; Sarason, 1980) that students' fear of evaluation, or test anxiety interferes in their test performance. It has been proposed

(Tobias, 1985c) that the cognitive representation of anxiety, and the tendency of test anxious students to divert their attention from the task to irrelevant concerns (Sarason, in press; Wine, 1980) ties up some portion of cognitive capacity. When task requirements and the demands of test anxiety exceed available capacity, students task performance declines. Therefore, any strategies which reduce the cognitive capacity required by the task should be differentially beneficial for highly anxious students. There is research support for these predictions in studies using a paired associate paradigm (Cubberly & Weinstein, 1983; Walters & Tobias, 1985).

Review is a strategy which may differentially beneficial for anxious students. Review should enable such students to attend to any segment of instructional input missed while they were diverted from the task (Tobias, 1979) by anxiety related pre--occupations. Furthermore, reviewing should reduce the task's demands on working memory by supplying an external representation of previously read material. These expectations were confirmed in non-reading tasks by Deutsch and Tobias (1980) who found that having the opportunity to review a series of video taped modules was differentially beneficial to anxious students. Oosthoeck and Akers (1973) found a positive correlation between the number of reviews of an audiotape and test anxiety.

There is also research relating test anxiety directly to review of reading. Tobias and Sacks (1983) found a correlation of .54 between worry, a component of test anxiety and students' review of text presented in booklet format. Tobias (1985b) found a positive relationship between test anxiety and number of mandatory text reviews. Therefore, an interaction was expected between the choice

variable and test anxiety; specifically, required review was expected to be differentially beneficial for anxious students compared to their less anxious counterparts.

Self-reports and Actual Strategy Use

A previous study (Tobias, 1985b) found few relationships between students' self-report of reading strategies and actual use of macroprocessing options. These data were at variance with those reported by Alexander, Hare and Garner (1980) who reported close correspondence between number of lookbacks and self-reports. The discrepancy between these results might be attributable to the fact that in the Tobias (1985b) study, students' self-reports were obtained regarding general reading strategies employed in different academic areas, rather than the computer-based reading task specifically. In order to test this possibility students in this study were also asked to report on the strategies used during the experimental task.

Method

Students were randomly assigned either to a required or an optional review condition, and within these to one of three types of instructional support for review. In addition, a number of tests and research instruments were administered.

Subjects

A total of 122 students participated in this experiment. Students were recruited from undergraduate classes at the City College of New York and paid $8.00 for their participation. The sample consisted of 75 females and 47 males, and had a mean age of 22.

Procedures

The experiment was conducted in two sessions. In the first, the following measures were administered: 1) Sarason's (1972) Test Anxiety Scale, 2) the Worry-Emotionality Scale (Morris, Davis, & Hutchings, 1980), 3) the Nelson-Denny Reading test (Brown, Bennett, & Hanna, 1981), 4) a multiple choice pretest assessing student's prior knowledge of the content in which instruction was to take place, 5) a questionnaire asking students about strategies customarily employed while reading in these three subject matter areas: English, Science, and Computer Science and Mathematics.

In the second session students were assigned to read a passage displayed on microcomputers. A Worry-Emotionality Scale was administered in the middle of the text. After completing the passage a posttest was given, followed by another Worry-Emotionality instrument in which students were asked to describe their feelings during the posttest. Finally, a questionnaire concerning student's use of the available options in the study was also administered.

Materials

The text consisted of a 49 paragraph, 172 sentence passage, describing some of the underlying generalizations dealing with data processing. A logical introduction to programming, illustrated by commands from the BASIC programming language was also provided. The passage was used in two earlier experiments (Everson & Tobias, 1985; Tobias, 1985b) and was written in a 14th grade vocabulary (Frye, 1968).

An alternate, easier passage consisted of 182 sentences written in a 10th grade vocabulary (Frye, 1968). Each paragraph of the alternate text was identical to that of the main passage. The

alternate passage rigorously used a structure consisting of superordinate- followed by subordinate sentences. Students could consult the alternate text after completing the comparable paragraph in the main passage, signalled by a beep from the computer's buzzer.

A posttest was administered in a paper and pencil format after students finished the text. The posttest required constructed responses and was subdivided into two parts: 1) A relevant section containing 26 items, in which the items were similar to the adjunct questions administered during the instructional program. 2) An incidental section of 25 items, dealing with material not covered by the adjunct questions. The reliability of the relevant and incidental sections of the posttest were determined to be .86 and .76 respectively in one prior investigation (Tobias, 1985b), and .87 and .85 in another (Everson & Tobias, 1985). In the present study the reliability was found to be .85 for the relevant posttest and .87 for the incidental posttest.

Experimental Conditions

Students were randomly assigned to either a required or an optional review condition; both groups were informed when they answered the adjunct question incorrectly. In the required condition students had to review the preceding screenful of text when their answer was wrong; in the optional condition students were asked whether they wanted to review the preceding material to correct their answers. Within these choice categories students were randomly assigned to three further conditions. In one of these the adjunct question was displayed at the bottom of the screen while students reviewed the preceding text. In the second, students were urged to "think" of the preceding question as they conducted their review. In

the third condition students were merely informed that they could or were required to review, depending upon their choice group. All conditions could terminate review and have the question be re-administered when they wished; otherwise the question was given again when students completed reviewing all of the preceding screenful of text. This part of the study, then, conformed to a 2 X 3 factorial design.

In the required review condition students were looped back for review twice if their answers to the adjunct questions were incorrect. If, after the second review, the answer was still wrong a research assistant examined the response for semantic similarity to the correct answer. If, in the judgment of the research assistant, the response was wrong students were required to make one further review. If the answer was still incorrect then, the correct response was supplied by the computer. Of course, when the adjunct question was answered correctly students could continue to read the next text segment.

Display of Materials. The text material was displayed in 22 screenfuls on Apple II+ and IIe computers, one sentence at a time. Each sentence was numbered and as soon as students depressed the spacebar the present sentence was erased, though its number and the space it occupied remained on screen, and the next sentence was displayed. At the bottom of the screen, a data line indicated the available options at that point. Each screenful of text was followed by an adjunct question requiring constructed responses. The questions covered facts, mastery of concepts, and applications of principles. Answers were considered acceptable if they gave evidence that the concepts had been mastered, irrespective of syntax or

spelling errors.

Students could exercise any of the following options while reading the text: 1) They could consult the alternate, easier text after completing the similar paragraph of the main passage signaled by a beep from the computer. 2) They could take notes on the computer system. 3) They could voluntarily review any part of the main text prior to being either required, or given the option to review in case of a wrong answer to the adjunct question. Voluntary reviews could be conducted in two ways: a) Whenever the backward arrow was touched the preceding sentence was displayed. b) Students could review a range of sentences already read. 4) The alternate text could be re-read by invoking the same procedures as in reviewing the main text. 5) Students could review their notes. 6) An options display describing the options available, and how they could be invoked could be consulted at any time.

A 45 sentence explanatory text was displayed prior to the instructional passage in the same manner as the instructional text, i.e., one at a time in numbered sentences. The explanatory material described the procedures of the study and the available options. Students were required to utilize every option at least once during the explanatory passage in order to assure that they understood the procedures. Option use was monitored to assure that students invoked the options correctly.

Results

The results may be divided into three sets of data: the effects of both the experimental variables, prior achievement, and test anxiety and their interaction on: 1) relevant and incidental posttest scores, 2) and on macroprocessing options. The third data set described the relationship between student reports of macroprocesses and options used in this experiment.

Achievement Results

The means and standard deviations for prior achievement, anxiety, and reading test data for the two choice groups, crossed with the three modes of review are displayed in Table 1. That table

---
Insert Table 1 about here
---

also shows the incidental and relevant posttest scores for these groups.

The results were analyzed by multivariate multiple regression analysis using the MANOVA program in the SPSSx Package (SPSSx, 1983) in which prior achievement, test anxiety, choice, review mode, and those interactions which were of theoretical interest were the predictors and posttest results the criteria. The results, shown in Table 2, revealed a highly significant multivariate main effect for

---
Insert Table 2 about here
---

pretest, as well as univariate effects for incidental and relevant posttest. Also, a significant triple interaction among choice, review mode, and worry was found. In addition, a significant

univariate triple interaction on the incidental posttest was found and is shown in Figure 1. Multivariate interactions among choice

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Insert Figure 1 about here

---

and pretest were also obtained though univariate analyses did not reveal significant interactions on either incidental or relevant posttest, thus, both are shown in Figure 2.

Insert Figure 2 about here

A multivariate interaction was also found for choice and test anxiety; univariate analyses revealed a significant interaction on incidental posttest score for these variables. That interaction is shown in Figure 3.

Insert Figure 3 about here

The multivariate interaction among choice, review mode and pretest was not significant, but univariate analyses indicated an interaction of borderline significance (F =2.87, df =2,101, p =.06) for the relevant posttest, which is shown in Figure 4.

Insert Figure 4 about here

Macroprocessing Results

The means and standard deviations of the number of sentences regarding which various macroprocessing options were invoked are shown in Table 3 for each of the six choice by review mode groups. In addition, Table 3 displays the correlations between option use

---

Insert Table 3 about here

---

and pretest scores with both total posttest and worry, a component of test anxiety. The significance of these differences was evaluated by multivariate multiple regression analysis, the results of which are displayed in Table 4.

Insert Table 4 about here

Surprisingly, there were no overall differences between either the choice or review mode groups, nor were any of the multivariate interactions significant. While the optional review groups re-read fewer main text sentences than those required to review, see Table 3, the variability of these data were very large, probably preventing these differences from approaching significance. As expected, pretest significantly affected reviews; those with higher pretest scores reviewed fewer main text sentences than students with lower pretest scores.

For the mandatory review group the total number of main text sentences re-read were composed of two subsets: Those sentences students were required to review when their answer to an adjunct question was incorrect, and voluntary reviews, or the sentences reviewed by students at any other time. A multiple regression analysis in which type of review were the predictors and posttest score the criterion indicated that the number of sentences students were required to review had a significant effect on posttest score, contributing a total of 49% of the variance (F= 54.42, p<.001). On the other hand, the number of sentences of

main text voluntarily reviewed was not significantly associated with posttest scores (F=.10), nor were the sentences of alternate text reviewed voluntarily significantly associated with posttest (F=1.04).

Since the optional review groups were not required to re-read all reviews were voluntary. However, it was also possible to divide the number of sentences re-read by this group into two categories: Sentences reviewed after incorrect answers to the adjunct questions and all others. In another multiple regression analysis the number of sentences reviewed after an incorrect answer accounted for 24% of posttest variance, (F=22.39,p<.001) for the optional review groups. None of the other reviews made by these groups contributed significantly to posttest score. That is, number of main sentences reviewed at times other than after an incorrect answer to the adjunct question (F=.66), or number of alternate sentences reviewed (F=.11) did not contribute significantly to posttest score.

There were a number of univariate interactions which approached significance. Specifically those between choice and pretest scores (F =3.06; df =1,101; p =.08) as well as between pretest and worry on the frequency with which the option menu was consulted (F =3.66, df =1,101; p =.06). Also review mode and worry had a marginally significant interaction on the frequency with which notes were reviewed (F =3.03, df =2,101; p =.053). Finally, the interaction among choice, review mode and pretest score on alternate text reviews (F =2.97, df =2,101; p =.06) was marginally significant. Since the multivariate interactions in each of these cases were not significant, and since a total of 54

univariate interactions were examined, the four interactions of borderline significance should be interpreted with caution.

Option Use and Student Self-Reports

Self-reports of reading strategies employed by students were obtained twice: 1) During the first session, prior to reading the passage, students were asked to complete a Likert-type scale regarding the reading strategies customarily employed while reading English, Science, and Mathematics and Computer Science texts. A copy of that scale appears as Appendix 1. 2) After completing the passage and the posttest students were asked to check off, on another Likert scale (Appendix 2), which strategies they had used while reading the text passage.

Relationships between responses to the first questionnaire and actual use of macroprocessing options were determined by computing correlations between options employed during the experiment and questionnaire responses in the three subject matter areas: English, Mathematics and Computer Science, and Science. Out of a total of 162 such correlations, only 4 were significant. Since the number of significant relationships was lower than could have been expected by chance it can be assumed that there were no significant relationships between students' self-reports of strategy use in these three subjects, and macroprocessing options used during this experiment.

Correlations were also computed between responses to the first and second questionnaire. These correlations were significant only for self-reports of the frequency with which the main passage was reviewed. Responses regarding main passage review were correlated with similar questions concerning reviewing materials in English (r =.35, p <.01), Science (r =.27, p <.01), as well

as in Mathematics and Computer Science (r =.34, p ...).
The other correlations between responses to the two questionnaires were not significant.

Table 5 shows the correlations of all students responses to post survey questions regarding use of macroprocesses with

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Insert Table 5 about here
---

comparable options available while students were reading the passage on the computer. It should be noted that correlations are displayed both for the frequency with which options were used, and for the number of sentences involved in option use.

The results revealed large differences in the relationships between the questionnaire administered after the experiment and actual option use for the six groups. These relationships are shown in Table 6.

Insert Table 6 about here

Discussion

The general hypothesis of this study was that instructional support for review would be more effective for students with low prior experience with the content, compared to more knowledgeable students. This hypothesis received partial support. A second hypothesis, that required review would be selectively beneficial to anxious students compared to those lower in anxiety, was generally supported by the results. There were no significant differences or interactions in the use of macroprocessing options. These findings will be discussed below.

Effects on Outcomes

Both requiring review and providing support for such review had been expected to improve achievement, especially for students with low prior knowledge of the the content. These procedures had also been expected to be differentially effective for students of different anxiety levels. These results will be discussed below.

Requiring Review. Previous research (Everson & Tobias, 1985; Tobias, 1985b) found highly variable and frequently ineffective use of reading strategies when use of options was left entirely to students' discretion. It was, therefore, anticipated in this and in the preceding investigation (Tobias, 1985b) that requiring students to review when their answers to adjunct questions were incorrect would improve their learning. The results did not support this expectation.

Contrary to the findings of prior research (Tobias, 1985b) there were no achievement differences between optional or required review on either posttest items related to the adjunct questions (relevant), or questions unrelated to the adjunct questions (incidental) posttest. In the previous study two required review groups outperformed students in optional review and reading conditions on relevant sections of the posttest. The differences in findings are probably attributable to the altered procedures for the optional review group. In the previous study, when a wrong answer to an adjunct question was made subjects were asked only whether they wanted to review prior text. In this study they were also asked, in addition, whether they wanted to correct their answer to the adjunct question, and then given the chance to make such corrections. These opportunities for correction and renewed answering of the question

led to a one third increase in the use of review by the optional review groups compared to the preceding study. In turn, the greater use of review in this study may have reduced posttest differences between the optional and required review groups.

The differences in outcome results between the present and preceding study may also be due to the absence of read-only groups in this experiment. In previous studies (Everson & Tobias, 1985; Tobias, 1985b) groups merely reading the content had lower posttest scores than others. Without a reading group the between groups variance was reduced to such a degree that the required-optional posttest differences were no longer significant.

Finally, the differences in findings may also be attributable to changes in the samples employed. The preceding study used high school students as subjects, whereas college students were employed in the present investigation. Such students may have been readier to review content in order to correct wrong answers, ultimately raising their scores on the relevant posttest.

Providing Criteria for Review. The generally ineffective use of strategies in prior research were partially attributed to students' inadequate internal representation of the subject matter. Specifically, it had been suggested that students, especially those with limited familiarity with the content, had some difficulty determining when they did, or did not comprehend what they read. Therefore, it was also expected that prompting students' to review by showing the preceding question, or asking them to think of it while reviewing would provide criteria against which to evaluate the adequacy of their review. Such support had been expected to lead to superior learning generally, and to be especially beneficial to

students with little prior experience with the subject matter. The results partially supported these expectations. Contrary to expectations, there were no overall outcome differences among the three review modes. Apparently, receiving additional support to conduct reviews did not lead to deeper and more accurate processing of subject matter than merely re-reading the text. Also, procedural changes linking feedback review, and the opportunity to correct answers to adjunct questions may have given students greater direction to correct their misconceptions and improve comprehension. In turn, these features may have reduced posttest differences among the review modes.

The marginally significant ($p.=.06$) interaction among choice, review mode and pretest (shown in Figure 4) on relevant posttest indicated that, as expected, being required to review generally led to superior achievement for students with low pretest scores. There were two exceptions to this generalization: 1) Students with low pretest scores, who were both required to review and instructed to think of the question while reviewing, had the lowest achievement compared to others with similar pretest scores. Presumably, for students with limited experience with this content such instructions led them to divide their attention between the text and recall of the adjunct question. The divided attention probably interfered with the learning of these students. 2) Unexpectedly, students in the optional, simple review group learned most at all levels of pretest score. Perhaps these students were stimulated by the suggestion to correct their wrong answers and re-read frequently when they experienced some confusion. Such voluntary attempts to make corrections may have induced a deeper level of processing than

other groups, leading to the highest posttest scores among s groups.

The multivariate interaction between choice and pretest score (depicted in Figure 2) indicates that, as expected, pretest was positively associated with posttest score for all groups. On the incidental portion of the posttest a disordinal interaction indicates that at upper pretest levels students required to review obtained somewhat higher scores than those for whom review was optional. The differences between the functions for the relevant and incidental data suggest that students in the optional review group were more effective in skimming for content relevant to the adjunct questions, whereas those with high pretest scores who were required to review learned somewhat more of the incidental content than those with the option to review.

Interactions with Anxiety. Required review had been expected to be especially beneficial to anxious students It has been hypothesized (Tobias, 1985c) that the cognitive representation of test anxiety absorbed some portion of cognitive capacity, leaving less capacity to be devoted to the task. Required review was expected to reduce the cognitive demands of the task, an reduce interference of anxiety.

The findings generally confirmed expectations. The interactions involving anxiety (Figures 1 and 3) indicated that as test anxiety increased the posttest performance of students with the option to review decreased, whereas for those required to review posttest remained largely unaffected by anxiety. Being required to review when answers to adjunct questions were incorrect enabled anxious students to perform as well, and in some cases even better than the

less anxious counterparts, despite the presence of anxiety. Required review may have enabled these students to focus on important aspects of the content missed, due to preoccupations with anxiety-related thoughts (Sarason, in press; Wine, 1980), in their initial pass through the material, thus improving learning. Required re-reading of the content apparently reduced the demands of the task on students' memory so that they were able to learn more effectively despite the demands on cognitive capacity made by test anxiety.

Macroprocessing Option Data

There were no differences between choice groups or among review modes on any of the macroprocessing options, nor were there any significant interactions for these data. These findings were strikingly different from a prior study (Tobias, 1985b) in which students required to review main text read approximately nine times more sentences than those for whom such review was optional. Furthermore, in the previous study a group required to review the alternate text re-read 20 times as many sentences as the optional review group.

In the optional review conditions of the preceding study students were merely informed whether their answers to adjunct questions were right or wrong, and then instructed to press any key to continue. A data line at the bottom of the screen informed them of various choices they could make at that time, including review. In the present study, in addition to being informed that they made an error, the optional review groups were asked whether they would like to review the preceding page in order to correct their answers, and were then given the opportunity to answer the question again. This linking of review with correction may be related to the more frequent

use of review by the optional review group in this study than in the preceding ones (Everson & Tobias, 1985, Tobias, 1985b) in this research program. Furthermore, the variability, with respect to the mean, of the review data in this study was substantially lower than in the preceding investigations. These results suggest that review was used more strategically in this studies, than in the preceding ones.

As indicated above, in the preceding study (Tobias, 1985b) the required review groups had higher posttest scores on the relevant posttest than did the optional review group. The fact that there were no differences in either achievement, or in amount of review between optional and required review groups in this study further suggests that review was used more strategically by students, hence reducing the posttest differences between these groups.

Self-Reports and Option Use

The results for the relationships between self-reports of strategy use and options actually used in this study revealed low relationships for the sample as a whole. The highest correlation (.53, $p < .01$) was between notes taken during the experiment, and self- reports of notes taken. The relationships between self-reports of option use during the experiment and actual use were higher than between reports of strategy use in general reading and those employed during the experiment. Nonetheless, the median relationship between reported and actual option use for the total sample accounted for less than 1% of the variance, and over half the correlations reported in Table 5 were not significant. Clearly, the results of this study and the preceding one (Tobias, 1985b) suggest that students' are not very aware of the strategies they use.

The low relationships between self-reports and actual use may be attributable to the fact that the data dealt with number of sentences involved in option use, and students might not have such a fine-grained awareness of their strategy use. Two types of data were collected to investigate this question: 1) Frequency with which options were invoked and, as in prior research, 2) number of sentences involved in such option use. In general, the correlations displayed in Tables 5 and 6 indicate that the relationships between these two indices of option use were quite similar. Therefore, the low relationship between self-reports and actual option use cannot be attributed to the precision with which computers recorded use of options. Apparently students did not have a clear awareness of their strategy use, at least in the present computer-based reading task. Whether their awareness would be higher if the same material were administered in a booklet format should be determined by further research.

The most striking aspect of the self-report and actual option use data was the large variability in correlations, displayed in Table 6, among the various groups. Differences among these sub-groups should be interpreted with caution because of the small number of cases in each group, and in view of the substantial variability for option use data. In general, correlations were slightly higher for the optional than for the required review groups suggesting that student awareness of strategy use was higher when options were invoked at their own discretion. Students required to review were free to use, or not use all the other options, as often as they wished. Despite that, self-report and actual use correlations for the optional review groups were higher for most of

the macroprocessing options available in the study. Since the required review groups had to re-read more often than those in the optional review groups, the greater use of review may have interfered with their recall of other option use, or with their need to use other strategies.

General Discussion

The experimental paradigm of reading text on microcomputers, and displaying the passage one sentence at a time was substantially different from students' habitual reading. Such variability raises questions whether the findings might be attributable to the conditions of this paradigm. The two preceding studies (Everson & Tobias, 1985; Tobias, 1985b) found, in accord with many other investigations (Anderson & Biddle, 1975; Andre, 1979; Hamilton, in press), that employing adjunct questions, with or without required review, improved achievement compared to reading the text without questions. As indicated above, the results regarding variable and ineffective use of reading strategies were also similar to those reported by other investigators (Baker & Anderson, 1982; Garner & Kraus, 1981-82; Nist & Hogrebe, 1984). These findings suggest that the experimental paradigm of displaying the passages on computers one sentence at a time had little effect in changing students' reading.

The three studies using this experimental paradigm have demonstrated that varying task condition such as use of adjunct questions, feedback, and requiring review did lead to the use of different types and frequencies of macroprocesses by students, one of the major questions posed previously (Tobias, 1982). Some results of

our earlier studies (Everson & Tobias, 1985), together with those of other investigators (Baker & Anderson, 1982; Garner & Kraus, 1981-82; Nist & Hogrebe, 1984) have suggested that, in situations in which students can freely chose strategies, they are often used ineffectively and infrequently, especially by students with limited prior knowledge of the content. When strategies use was prescribed, they were used more often, but not much more effectively.

The present study has indicated that offering students the opportunity to correct their answers apparently prompted them to be more strategic and effective in their use of review. In optional review conditions students re-read more text than in prior studies and the variability of review was reduced. Furthermore, the greater use of review probably led to a reduction in learning differences between optional and required review conditions. Research in field contexts (Palincsar, 1985; Palincsar & Brown, 1984; Paris, Cross & Lipson, 1985) have found that training helps poor readers use strategies more effectively. These results suggest that it may be fruitful to investigate whether instructing students in the use of review in this computer administered instructional research context will also lead to improvements in comprehension and in use of strategies.

Table 4.1 Means and Standard Deviations of Selected Dependent and Independent Variables.

		Optional			Required		
		Simple Review N=23	Think of Question N=21	Question Visible N=24	Simple Review N=16	Think of Question N=20	Question Visible N=18
Variables							
Incidental Posttest	M	12.80	13.90	13.65	13.72	13.48	11.42
	SD	6.88	4.69	5.68	6.40	6.57	6.42
Relevant Posttest	M	18.28	17.65	17.35	18.14	17.30	16.70
	SD	5.33	5.23	5.63	5.37	5.62	4.23
Total Posttest	M	31.09	31.56	30.99	31.85	30.78	28.12
	SD	11.85	9.25	10.78	11.10	11.76	10.36
Pretest	M	19.09	22.05	21.08	20.19	23.30	19.00
	SD	7.41	5.26	5.54	4.07	5.87	7.60
Worry Program	M	9.39	8.33	9.08	8.88	9.65	9.50
	SD	3.86	3.62	4.24	4.53	3.99	5.08
Worry Posttest	M	10.78	9.67	8.29	9.31	7.90	10.72
	SD	4.03	4.26	5.51	3.99	5.73	5.52
Nelson Denny*							
Vocabulary	M	52.61	45.95	47.04	45.50	42.90	42.83
	SD	23.17	22.55	21.20	18.82	22.01	15.03
Compre-hension	M	38.65	30.67	35.42	38.38	36.60	36.56
	SD	14.83	14.61	12.93	13.03	13.33	12.88
Total	M	91.26	76.62	82.46	83.88	79.50	79.39
	SD	36.20	36.07	31.76	29.86	33.65	24.22

*Raw Score

Table 4.2 Multivariate and Univariate Results of Posttest.

		Univariate Results Posttest	
Independent Variables	Wilk's Lambda	Incidental	Relevant
Choice (C)	.994	<1	<1
Review Mode (R)	.960	<1	<1
Pretest (Pre)	.581**	69.75**	55.3e**
Worry (WP)a	.975	2.05	2.46
C X Pre	.895**	3.09	<1
C X WP	.929*	7.16**	2.30
C X R	.963	<1	<1
Pre X WP	.954	<1	3.64b
R * Pre	.964	<1	<1
R * WP	.971	<1	<1
R * Pre * WP	.974	<1	<1
C * R * Pre	.942	2.43	2.87b
C * R * WP	.869**	5.23**	<1

a) Worry scale administered after posttest.

b) p.=.06

** p. <.05

* p. <.01

Table 4.3 Means and Standard Deviations and Correlations [illegible] Posttest, Pretest and Worry for Option Use Data.

		Optional			Required		
		Simple Review	Think of Question	Question Visible	Simple Review	Think of Question	Question Visible
Main Text Reviews[1]	M	75.13	65.38	68.54	87.50	73.25	79.13
	SD	41.49	36.98	32.51	61.74	53.69	43.38
r Posttest		-.43	-.07	-.45	-.81**	-.75**	-.50
r Pretest		-.41	-.06	-.20	-.53	-.65*	-.30
r Worry[2]		.41	-.17	.19	.27	.52	-.29
Alternate Text Reviews[1]	M	4.45	4.25	4.71	4.70	5.20	3.25
	SD	12.18	14.57	12.98	9.17	10.73	3.79
r Posttest		.28	-.21	.35	.21	.17	.10
r Pretest		.23	-.11	.39	.41	.24	-.09
r Worry		-.17	-.27	.10	-.16	-.03	.21
Inspection of: Alternate Text[1]	M	13.13	9.57	17.62	11.62	12.75	6.61
	SD	23.95	23.71	35.77	28.31	34.74	22.26
r Posttest		.40	.22	.19	.19	.02	-.19
r Pretest		.16	.12	.15	.44	-.08	-.05
r Worry		.01	-.12	.16	-.36	.24	.21
Notes[1]	M	3.39	3.71	3.04	1.50	3.90	4.94
	SD	7.20	7.04	4.43	2.55	5.68	8.88
r Posttest		-.03	-.05	.00	.20	.30	.36
r Pretest		-.40	-.26	.27	.27	.23	.40
r Worry		-.04	-.37	.04	-.30	-.17	.02
Review Notes[1]	M	.39	.47	.16	.31	.20	.55
	SD	1.03	1.12	.56	.79	.69	1.34
r Posttest		-.01	-.14	.26	.25	.27	.40
r Pretest		-.16	-.03	.38	.33	.31	.14
r Worry		-.14	-.26	-.12	-.25	-.28	.21
Options Menu	M	.87	.71	.83	.31	.35	1.27
	SD	1.84	1.58	2.25	.79	.93	2.88
r Posttest		-.13	-.05	-.13	.00	.16	.10
r Pretest		-.20	.21	-.20	.25	.22	-.06
r Worry		.13	.03	-.03	-.16	.13	.14

1 Number of sentences

2 Worry scale administered during program

** p. <.01

* p. <.05

Table 4.4 Multivariate and Univariate Analyses of Variance of Option Utilization Data.

		Univariate Results					
Independent Variables	Wilk's Lambda	Main Text Reviews	Alternate Text Reviews	Inspection of Alternate Text	Notes	Review of Notes	Optic Menu
Choice (C)	.987	<1	<1	<1	<1	<1	<1
Review Mode (R)	.911	<1	<1	<1	1.79	1.33	1.42
Pretest (Pre)	.915	6.76*	1.41	1.49	<1	<1	<1
Worry (W)a	.991	<1	<1	<1	<1	<1	<1
C * Pre	.940	3.06	<1	<1	2.27	1.37	1.21
C * W	.979	<1	<1	<1	<1	<1	<1
C * R	.934	<1	<1	<1	<1	1.29	<1
Pre * W	.953	<1	<1	<1	2.12	<1	3.66
R * Pre	.919	1.92	<1	<1	<1	<1	<1
R * W	.898	1.02	<1	1.48	<1	3.03	<1
R * Pre * W	.914	<1	1.94	<1	<1	2.58	<1
C * R * Pre	.906	1.09	2.97	<1	<1	<1	<1
C * R * W	.912	1.32	<1	<1	<1	<1	<1

a) Worry scale administered during reading.
** p. $\leq$ .01
* p. $\leq$ .05

Table 4.5 Correlations Between Self-Reports of Macroprocesses with Comparable Option Use for Total Sample.

	Option Use Data	
	No. of Sentences	Frequency of Option Use
Questionnaire Responses		
Read Alternate Passage	.50**	.41**
Reviewed Main Passage	-.02	.02
Reviewed Alternate Passage	.21	.21
Options Menu	---	.07
Took Notes	---	.53**
Reviewed Notes	---	.18

** $p < .01$

Table 4.6 Correlations Between Questionnaire Responses and Comparable Option Use.

	Optional			Required		
	Simple Review N=23	Think of Question N=21	Question Visible N=24	Simple Review N=16	Think of Question N=20	Question Visible N=18
Questionnaire Responses and Option Use Data						
Alternate Text Sentences Read	.43	.66*	.58*	-.03	.34	.02
Frequency Alternate Text	.36	.64*	.61*	-.06	.32	.06
No. of Main Passage Sentences Reviewed[1]	-.10	.14	.56**	-.13	.20	-.29
Frequency of Reviews	-.06	-.05	.56**	-.20	.36	-.01
No. of Alternate Sentences Reviewed[1]	.18	.48	.11	-.18	.16	-.14
Frequency of Alternate Review	.16	.46	.03	-.17	-.12	-.14
Frequency of Notes	.73**	.50	.27	.05	.67*	.68*
Frequency of Note Review	.10	.48	.05	-.01	.15	.17
Frequency of Option Use	.22	.06	.07	-.16	-.11	.39

[1] Number of Sentences

** $p. < .01$
* $p. < .05$

Figure Captions

4.1 Interaction among choice, review mode, and worry on incidental posttest.

4.2 Multivariate interaction between choice and pretest on incidental and relevant posttest.

4.3 Interaction between choice and test anxiety on incidental posttest.

4.4 Interaction among choice, review mode, and pretest on relevant posttest.

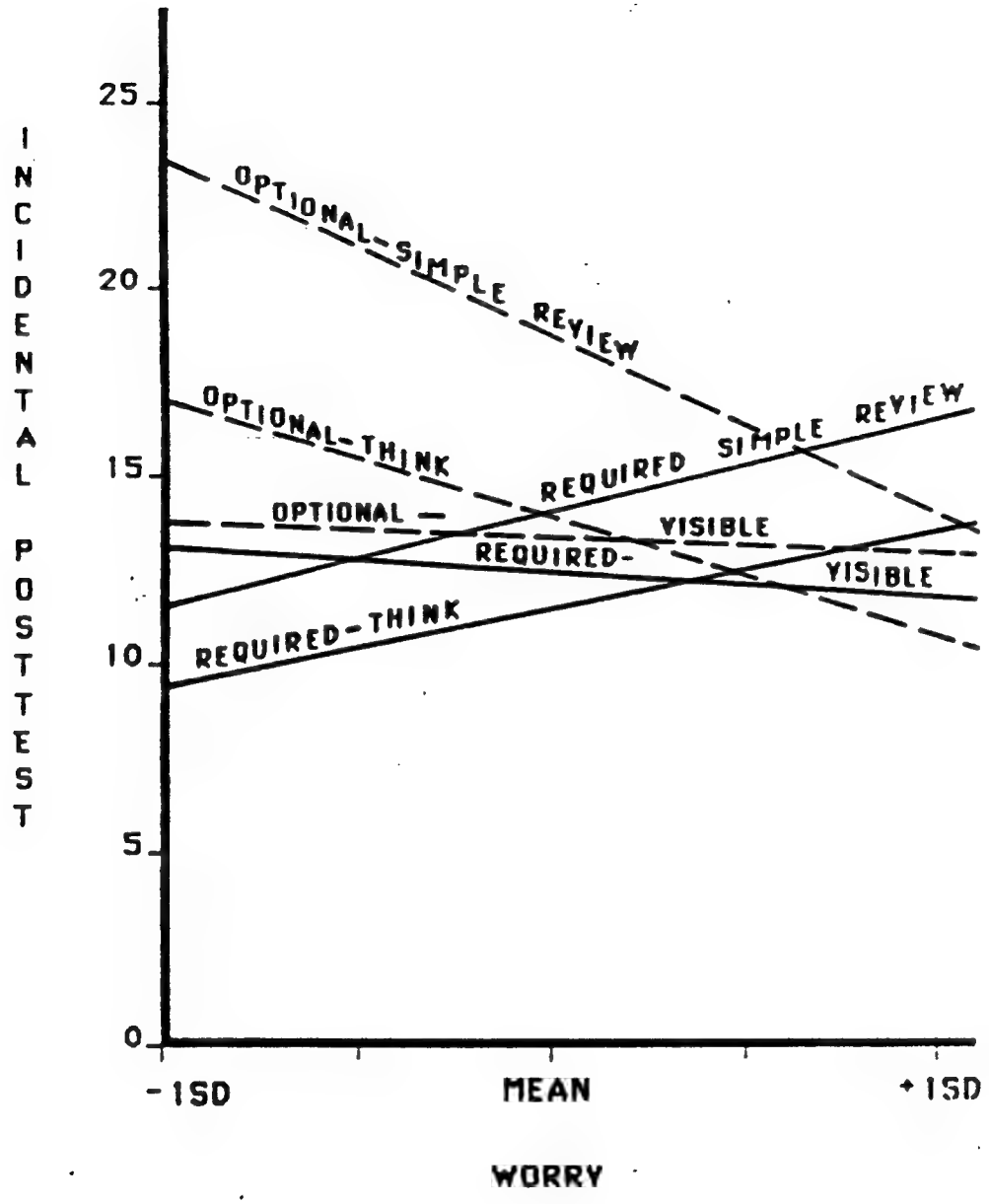
INCIDENTAL POSTTEST
25
20
15
10
5
0
OPTIONAL-SIMPLE REVIEW
OPTIONAL-THINK
REQUIRED SIMPLE REVIEW
OPTIONAL
VISIBLE
REQUIRED-
VISIBLE
REQUIRED-THINK
-1SD
MEAN
+1SD
WORRY

FIGURE 4.1

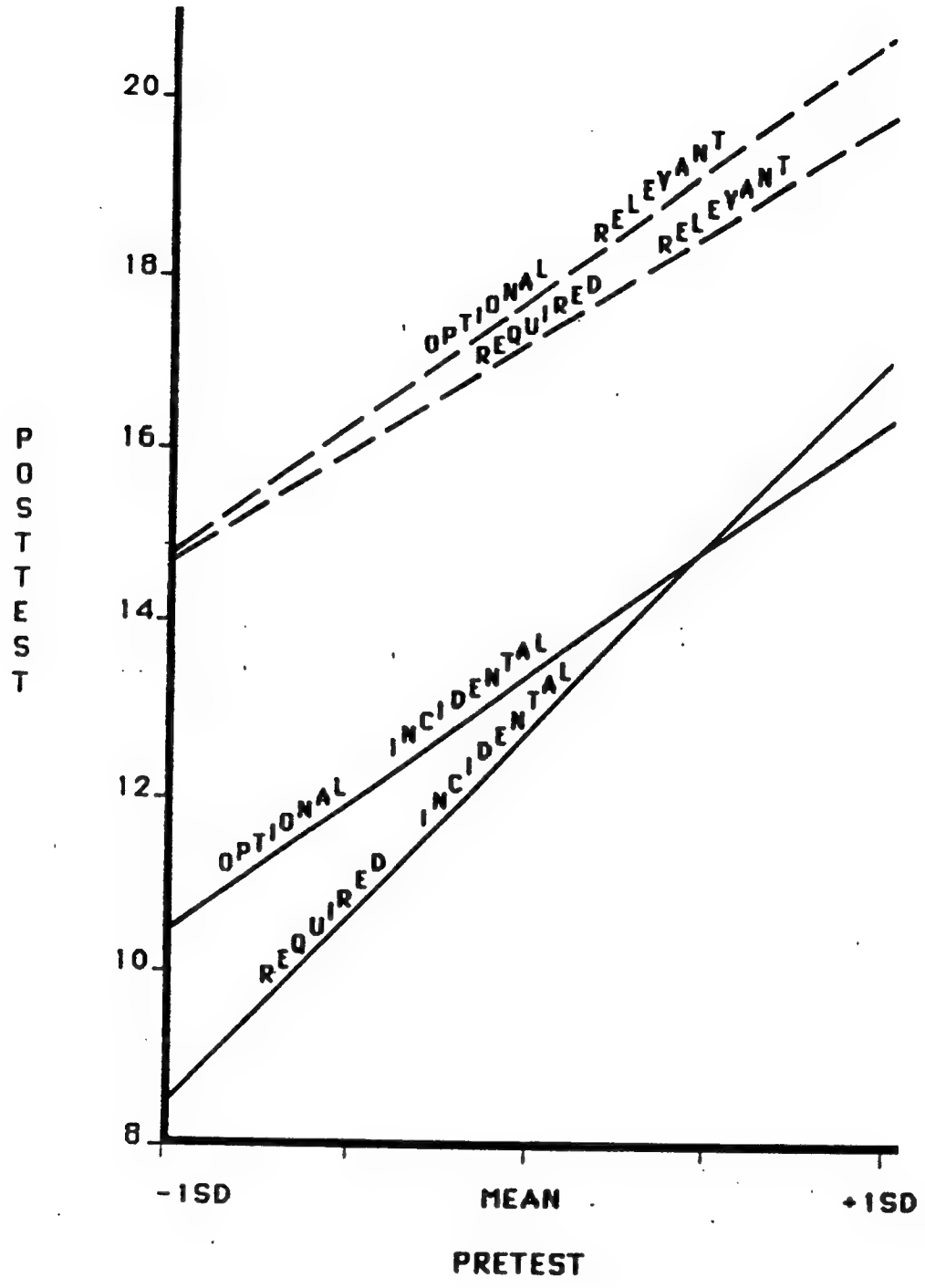
20
18
16
14
12
10
8
POSTTEST
OPTIONAL RELEVANT
REQUIRED RELEVANT
OPTIONAL INCIDENTAL
REQUIRED INCIDENTAL
-1SD
MEAN
+1SD
PRETEST

FIGURE 4.2

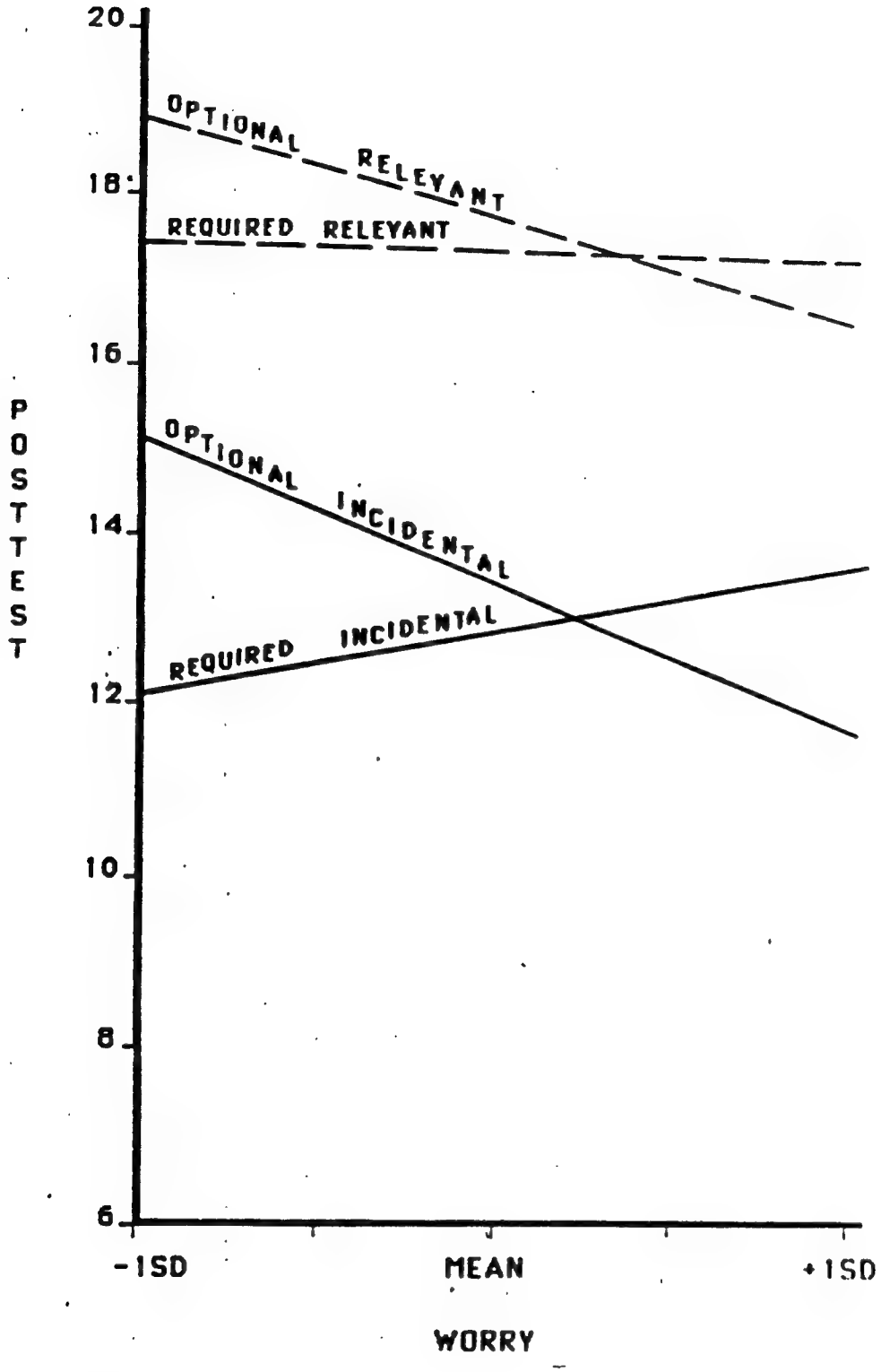
20
18
16
14
12
10
8
6
POSTTEST
OPTIONAL RELEYANT
REQUIRED RELEYANT
OPTIONAL INCIDENTAL
REQUIRED INCIDENTAL
-1SD
MEAN
+1SD
WORRY

FIGURE 4.3

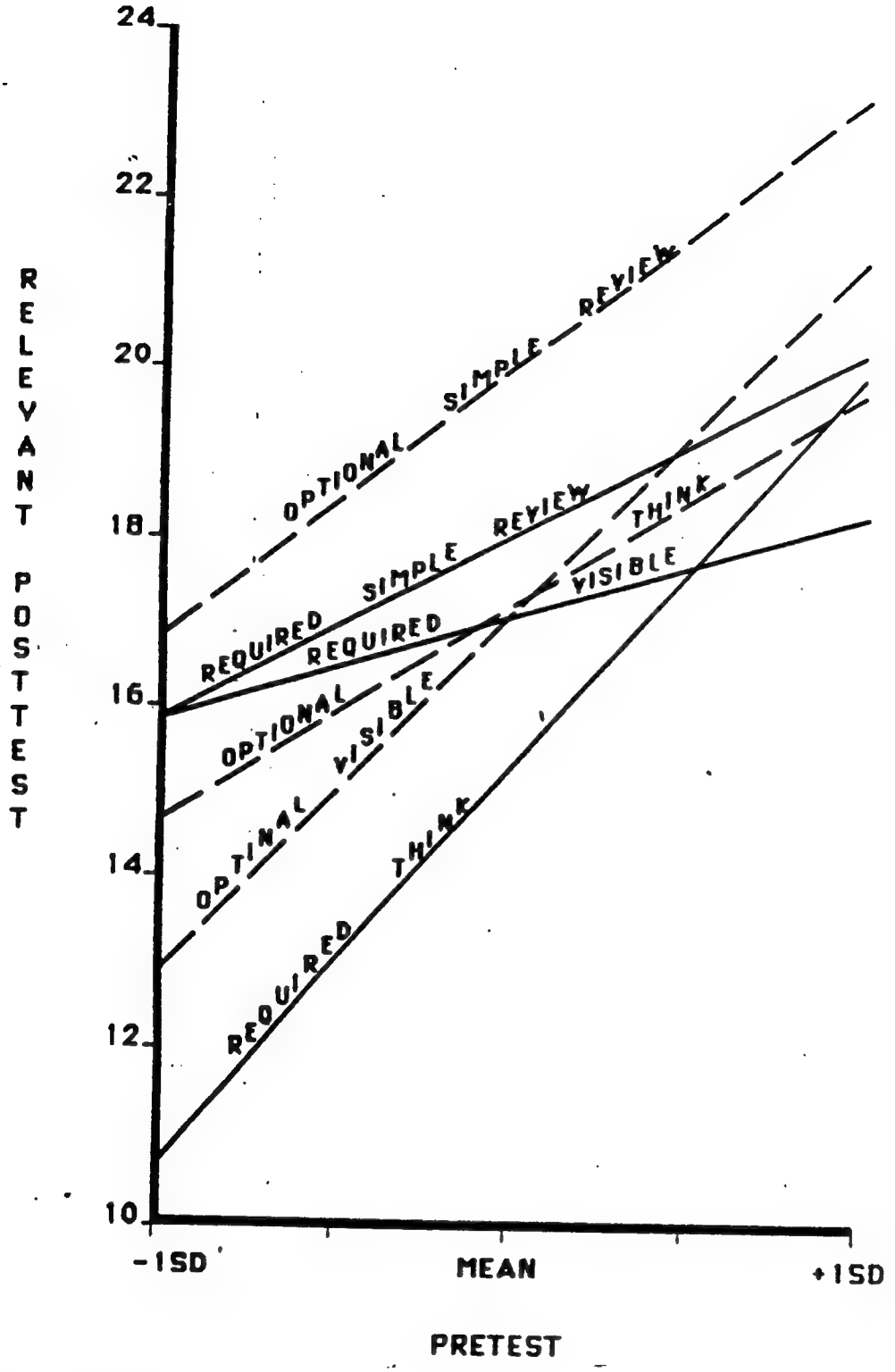
24
22
20
18
16
14
12
10
RELEVANT POSTTEST
OPTIONAL SIMPLE REVIEW
REQUIRED SIMPLE REVIEW
OPTIONAL THINK VISIBLE
REQUIRED VISIBLE
OPTIONAL THINK
REQUIRED THINK
-1SD
MEAN
+1SD
PRETEST

FIGURE 4.4

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Instructions

Below are a number of strategies used by students while reading. Pleas
indicate how often you use each of these strategies in different subjects.

In mathematics or the computer area how often would you do any of t
following? (Please check the appropriate box)

	All of the Time	Most of the Time	Some of the Time	Never
Reread				
Prepare Summaries				
Take notes				
Review				
Try to find an easier description				
Use a dictionary				
Underline				
Ask help from someone				
Answer study questions				

Other (Please describe) _____

_____

When reading for English classes how often would you do any of the following? (Please check the appropriate box)

	All of the Time	Most of the Time	Some of the Time	Never
Reread				
Prepare summaries				
Take Notes				
Review				
Try to find an easier description				
Use a Dictionary				
Underline				
Ask help from someone				
Answer study questions				

Other (Please describe) _____

_____

In science, how often would you do any of the following? (Please check appropriate box)

	All of the Time	Most of the Time	Some of the Time	Never
Reread				
Prepare summaries				
Take notes				
Review				
Try to find an easier description				
Use a dictionary				
Underline				
Ask help from someone				
Answer study questions				

Other (Please describe) _____

Please pick the choice that best describes your feelings and indicate the number in the space provided.

_____ Please rate your reading speed.

1. Very good
2. Good
3. Average
4. Fair
5. Poor

_____ Please rate your ability to understand what you read.

1. Very good
2. Good
3. Average
4. Fair
5. Poor

_____ Please rate your overall reading ability.

1. Very good
2. Good
3. Average
4. Fair
5. Poor

Post Survey

ID # _____ Name _____

Please check how often you used all of the options while you were reading the passage on the computer.

	Very Often	Often	Sometimes	Rarely	Never Often
1. Read the alternate passage.					
2. Took Notes.					
3. Reviewed the main passage.					
4. Reviewed the alternate passage.					
5. Reviewed notes.					
6. Looked at the description of the options.					

Please pick the choice that best describes what you did, and write t number in the space provided.

_____ 7. Did you use each of the options in order to increase your understanding of
1. a sentence.
2. a paragraph.
3. a screenful.
4. other (please specify). _____

_____ 8. I selected the options
1. in order to reinforce my understanding.
2. out of curiosity.
3. just for fun.
4. other (please specify). _____

_____ 9. Did you use the alternate text to increase your understanding of a
1. sentence in the main text.
2. paragraph in the main text.
3. screenful in the main text.
4. other (please specify). _____
5. Never used alternate text.

_____ 10. When you used the alternate text, did you try to
1. clarify confusing main text.
2. read the material in an easier format.
3. both 1 and 2.
4. Other (please specify). _____
5. Never used alternate text.

_____ 11. When did you take notes?
1. To remember the text better.
2. To rephrase the material in your own words.
3. To write down the main points.
4. Other (please specify). _____
5. Did not take notes.

_____ 12. Did you review the alternate text in order to increase your understanding of
1. a sentence.
2. a paragraph.
3. a screenful.
4. other (please specify). _____
5. Never reviewed alternate text.

_____ 13. Did you review your notes in order to increase your understanding of
1. a sentence.
2. a paragraph.
3. a screenful.
4. other (please specify). _____
5. Never reviewed notes.

_____ 14. Did you review the main text when
1. a sentence was confusing.
2. a paragraph was confusing.
3. a screenful was confusing.
4. Other (please specify). _____
5. Never reviewed main text.

_____ 15. Think of the material you read on the computer. Please estimate how much of it you have mastered.
1. All of it.
2. 3/4.
3. 1/2.
4. 1/4.

_____ 16. How did you feel about the way the material was presented?
1. Enjoyed presentation.
2. Presentation moderately pleasant.
3. Presentation moderately unpleasant.
4. Disliked presentation.

_____ 17. Did you find yourself trying to get through the material, rather than trying to learn?
1. All of the time.
2. Most of the time.
3. Some of the time.
4. Never.

_____ 18. Would you like to learn other material in a similar format?
1. Definitely.
2. Probably.
3. Probably not.
4. Definitely not.

_____ 19. Would you prefer reading the same material in a textbook?
1. Definitely.
2. Probably.
3. Probably not.
4. Definitely not.

_____ 20. How did you feel about the options provided on the computer?
1. Very helpful.
2. Helpful.
3. Somewhat helpful.
4. Not too helpful.

_____ 21. On a test of what you have read on the computer, what grade would you expect?
1. A
2. B
3. C
4. D
5. F

_____ 22. Once you got used to them, the options were:
1. very easy to use.
2. easy to use.
3. difficult to use.
4. very difficult to use.

_____ 23. Were there other options you would have liked to have? Please list them below.

_____

_____

_____

_____

_____

Chapter 5: Experiment IV.

Review Instruction, Comprehension Monitoring, and Student Characteristics

Sigmund Tobias

Abstract

The purpose of this study was to examine the effects of explaining the value of review and its interaction with different text presentation modes and student characteristics. Half of a sample of 130 high school students were randomly assigned to receive an explanation of the value of review and to read a passage displayed by computer in one of three modes: without adjunct questions, adjunct questions and prompted review, and required review when answers to adjunct questions were incorrect. Overall differences attributable to mode of responding were found, and an interaction between explanation and pretest indicated that those with limited prior knowledge profited more from having an explanation of the value of review than more knowledgeable students. There were differences in number of sentences reviewed attributable to response modes and interactions of processes used by students with pretest. The implications of these results for ATI research, and for the improvement of student comprehension were discussed.

When students have difficulties with their reading the strategy most frequently used to clear up the problem is to review prior reading. Despite its prominence there is relatively little research concerning the effects of review, or whether students can be instructed to use review to improve their comprehension, or of the relationship between review and a variety of student characteristics. It is to the clarification of these questions that the present study is directed.

Review of the Literature

A number of studies (Tobias & Sacks, 1985; Tobias, 1985a, Tobias & Everson, 1985) have examined students' use of macroprocesses while learning from reading. Macroprocesses have been defined (Tobias, 1982) as the relatively molar cognitive processes used by students during meaningful learning such as review, preview, taking notes, and others. These studies employed a paradigm in which students' use of macroprocesses was unobtrusively monitored during their reading. Text was displayed on microcomputers which also monitored students' use of options, the operational definition of macroprocesses. Available options included review, reading an alternate, easier text dealing with the same content, review of the alternate text, taking notes, reviewing those notes, and requesting a display showing each of the options and how they could be invoked. The text used in these

investigations consisted of 172 sentences, written in a 14th grade vocabulary (Frye, 1968). The alternate text was written in a 10th grade vocabulary and its organization followed a structure in which superordinate sentences preceded subordinate sentences in every paragraph.

In the first of these studies, Tobias and Everson (1985) employed three conditions: a group receiving adjunct questions after every screenful of text, a second group which obtained feedback regarding the accuracy of their answers to adjunct questions, and a reading group which read the text without adjunct questions. The results indicated that the groups receiving questions had higher posttest scores than the reading group. Neither review, nor any of the other macroprocessing options helped students process the text more effectively; i.e., options were <u>not</u> related to posttest, nor to measures of prior knowledge or test anxiety. Option use was also found to be extremely variable. A number of significant interactions dealing with option use indicated that students who were high on both pretest and test anxiety used alternate text and headings more frequently than others.

A second study (Tobias, 1985a) examined whether prescribing review when students experienced comprehension difficulties improved achievement. Two groups were required to review (one the main and the other the alternate text) when they gave incorrect answers to adjunct questions. The mandatory review groups had higher scores on posttest items covering materials related to the adjunct questions than either an adjunct question or a reading group. Analysis of students' voluntary and mandatory reviews indicated that voluntary re-reading was <u>not</u> significantly associated with learning for any of

the four groups, whereas mandatory reviews contributed substantially to outcomes. Finally, interactions indicated that the number of mandatory reviews increased for anxious students, compared to their less anxious counterparts.

Even though the results indicated that learning could be improved by requiring review when answers to adjunct questions were incorrect, students did not use review very strategically in the Tobias (1985a) study. The mandatory review groups re-read up to 20 times more sentences than students in other groups in order to raise their posttest score by a few points, hardly a strategic use of review. On the other hand, there was also evidence of strategic behavior in that study. The results indicated that during re-reading students skimmed for the right answer to adjunct questions rather than reviewing all of the text systematically. Furthermore, knowledgeable students voluntarily read the alternate, easier text more frequently in order to avoid being required to review.

It was hypothesized in a succeeding study (Tobias & Sacks, 1985) that variable and ineffective use of macroprocesses by students may be a function of ambiguity regarding the meaning of comprehension. That is, when guidelines are provided against which students can assess their comprehension, strategic use of macroprocesses to improve learning should become evident. In the absence of clear criteria, students' uncertainty regarding mastery of the subject matter was expected to lead to more variable use of macroprocesses. Voluntary and required review were compared in three different review modes: 1) Simple review, when answers to adjunct questions were incorrect. 2) Instructing students to think of the adjunct question during review. 3) Displaying the prior question during review.

Unlike the prior studies, all students were prompted to use review to improve their comprehension. In the voluntary condition, the prompting consisted of asking students whether they would like to re-read in order to correct a wrong answer to a preceding adjunct question; in the mandatory condition, students were required to make those reviews.

The results indicated that there were no differences in posttest scores, number of sentences reviewed, or use of other macroprocesses attributable to choice or review modes. Apparently, prompting students to review in order to correct answers to adjunct questions induced them to re-read many more sentences compared to similar groups in prior studies. More frequent re-reading in the voluntary review condition also reduced the variability associated with reviews in prior investigations and apparently also decreased differences between voluntary and required review conditions in posttest scores. In the mandatory review groups, required re-reading was strongly associated with increases in posttest score, contributing approximately 46% of the variance. Voluntary reviews, however, were not significantly related to improved learning. A similar analysis in the optional review groups indicated that prompted re-reading after an incorrect answer contributed significantly to posttest, whereas all other reviews were not significantly associated with outcomes.

In view of the apparent effectiveness of prompting in leading students to review more strategically, the present research examined whether some general explanation about the value of review would also lead to improved comprehension. It was expected that such explanation would be especially beneficial to students with limited

prior knowledge of the text. Finally, the results of providing such explanations were also expected to provide evidence regarding ways in which review could be made strategic in more conventional reading situations.

Related Research

The results from the experimental paradigm described above are similar to other research on reading using different procedures. For example, findings that students' voluntary use of macroprocesses tends to be relatively random and ineffective have been reported by other investigators. Both Baker and Anderson (1982), as well as Garner and Kraus (1981-82) found that the majority of secondary school and college students do not detect inconsistencies in text. Similarly, Nist and Hogrebe (1984) reported that college students were unable to use adjunct questions and headings to improve their achievement. In an investigation of the use of reading strategies among seventh graders, Hare and Smith (1982) found that no student reported the use of more than two strategies. A negative relationship between recall and number of strategies reported was also found. Finally, Meyer, Brandt, and Bluth (1980) reported that less than 50% of their subjects used text structure strategies more than once; furthermore, only 22% used strategies consistently on four separate protocols.

A number of researchers have also reported similarly ineffective use of "lookback," or review strategies among readers. Garner and Reis (1981) found that only 30% of seventh grade good readers looked back at prior text in order to answer questions and only 9% of the poor readers did so. Alexander, Hare and Garner (1984) reported that among college students who were good readers only 30% looked back at

preceding text; 50% never looked back under any conditions.

These studies reported variable and ineffective use of processes when students were not trained or prompted in strategy use. A number of other investigations examined the effectiveness of training or prompting students to use various strategies, and their effect on learning. For example, Garner, Hare, Alexander, Haynes, and Winograd (1984) taught 11 year old children who were remedial readers why, when, and where to use lookbacks. Testing five days after instruction indicated that students employed lookbacks when they needed them and were significantly more accurate on questions involving text lookback than a control group of comparable readers. Alvermann and Van Arnam (1984) found that a graphic organizer, which re-directed the reader to the appropriate text in order to answer questions, facilitated the achievement of poor comprehenders.

Palincsar and Brown (1984) and Palincsar (1985) investigated students' acquisition of metacognitive strategies. Their training program consisted of these four steps: 1) Students were required to summarize what was read and 2), to formulate potential questions about text content. 3) Students received clarification when comprehension faltered and 4), were taught to predict the content of upcoming text. The program was found to be successful in helping students acquire metacognitive strategies to improve their comprehension.

Paris, Cross, and Lipson (1985) also reported gains in comprehension as a result of a cognitive strategies training program. Stevens (1984) found that metacognitive training generalized to students' reading of text which was different from that used in the original training program. Weinstein and Rogers (1984) developed

college level programs to teach students to monitor comprehension and use learning strategies. They reported increased scores on standardized measures of vocabulary and reading comprehension, as well as greater retention of course material.

These results indicate that training or suggesting the use of strategies to students increased their utilization. In turn, strategy use led to higher comprehension compared to situations in which use of strategies was left entirely to students' initiative. These results were, similar to those obtained from the research paradigm employed in this study and led to the expectation that providing explanations of the value of review would improve students' learning.

Interactions with Student Characteristics

This study was also stimulated by research on the interaction between student characteristics and instructional treatments, commonly abbreviated as ATI research, and by investigations of the effects of anxiety on meaningful learning. An analysis of ATI research (Tobias, 1982) identified many problems including the presence of an approximately equal number of positive and negative findings, marked difficulties in replicating research, or in generalizing from it. These problems were attributed to two assumptions present in most ATI studies: First, that different instructional methods demanded different macroprocesses. Second, that the macroprocesses were differentially available to students of varying characteristics. Only if these two assumptions are independently verified, as they rarely are in ATI research, can interactions be obtained. It was, therefore, suggested that further research was required to identify the processes demanded by different

instructional methods and available to students in order to advance ATI research. This was the general purpose of the research program of which this study was a part.

A general ATI hypothesis (Tobias, 1976, 1982) predicted an inverse relationship between prior achievement and the instructional support provided by different methods. Instructional support was defined as providing assistance to students in such things as maintaining their attention, helping them organize and recall what they were taught, or providing feedback regarding their mastery. It was expected that students with minimal prior experience in an area would learn optimally from instructional methods providing substantial instructional support. Knowledgeable students, on the other hand, were expected to learn as effectively from instructional methods providing considerably less support. The explanations, prompted and required reviews, as well as the macroprocesses to be investigated in this study were assumed to be forms of instructional support which would be differentially beneficial to students with limited prior experience with the content.

Preceding studies in this research program (Tobias & Everson, 1985; Tobias, 1985a; Tobias & Sacks, 1985) provided some support for the ATI hypothesis described above. When students were free to use the macroprocessing options voluntarily (Tobias & Everson, 1985), little relationship between prior knowledge and use of macroprocesses was found. A tendency emerged suggesting that students with high prior knowledge used the macroprocesses more frequently and generally benefited from them to a greater degree than those with less familiarity with the content. On the other hand, when use of macroprocesses was required or prompted by the instructional methods,

students with limited prior experience benefited most from their use.

The predicted inverse relationship between prior achievement and instructional support was expected to occur mainly if students were instructed in the effective use of macroprocesses (Tobias, in press). Therefore, in this study it was predicted that explanations about the benefits of review should be more helpful to students with limited prior knowledge of the content compared to those who were more familiar with it. Thus, interactions between receiving an explanation regarding the value of review and prior knowledge, and between prior knowledge and the degree to which option use was either voluntary or mandatory were expected.

There is also research documenting a relationship between review of reading and test anxiety. Tobias and Sacks (1983) found a correlation of .54 between worry, a component of test anxiety, and the number of times students reviewed text. Tobias and Sacks (1986) found that as test anxiety increased the learning of students with an option to review text decreased, whereas for students required to review posttest performance remained largely unaffected by anxiety. Being required to review when answers to adjunct questions were incorrect appeared to enable anxious students to perform as well, and in some cases even better than those less anxious, despite the presence of anxiety. Therefore, a similar interaction between required review and anxiety was expected in this investigation.

Method

The study conformed to a 2 X 3 factorial design in which the first level was defined by the presence or absence of explanations about the value of review and the second level consisted of three different text presentation modes. In addition, data regarding prior

knowledge of the content, test anxiety, and reading ability were obtained by questionnaire.

Materials

The text consisted of a 49 paragraph, 172 sentence passage describing some underlying generalizations dealing with data processing and computer programming. Illustrations of some concepts with instructions from the BASIC programming language were also provided. The passage was used in three earlier experiments (Tobias & Everson, 1985; Tobias, 1985a; Tobias & Sacks, 1985).

The main text was written with a 14th grade vocabulary (Frye, 1968). An alternate easier passage consisted of 182 sentences and was estimated to be of 10th grade (Frye 1968) difficulty. Every paragraph of the alternate text was identical to the comparable paragraph of the main passage. The alternate passage was structured so that superordinate sentences were regularly followed by subordinate sentences. Students could consult the alternate text after completing the comparable paragraph in the main text, signalled by a beep from the computer's buzzer.

A total of six options were available. 1) Students could read the alternate text, described above. 2) They could review the main text in one of two ways: a) Whenever the backward arrow was touched, the preceding sentence was displayed. b) Students could also request review of a range of sentences by typing the numbers of the sentences they wished to re-read (i.e., sentence 17-23). 3) The alternate text could be reviewed in the same manner as the main text. 4) Notes could be taken on the computer screen and 5) the notes could be reviewed whenever students wished. 6) Finally, students could inspect a menu describing each of the options and how they were invoked.

A posttest, requiring fill-in responses, was administered in a paper and pencil format after students finished the text. The subtest was divided into two parts: 1) A relevant posttest of 26 items covered material related to the content of the adjunct questions. 2) An incidental subtest of 25 items dealt with parts of the passage which were not the subject of adjunct questions. The alpha reliability of the relevant and incidental sections of the posttest were found to be .86 and .76 in one prior investigation (Tobias, 1985a), .87 and .85 in another (Tobias & Everson, 1985), and .85 and .87 in a third study (Tobias & Sacks, 1985).

Procedures

The experiment was conducted in two sessions: in the first the following measures were administered 1) Sarason's (1972) Test Anxiety Scale. 2) The Worry-Emotionality Scale, a state measure of test anxiety (Morris, Davis, & Hutchings, 1981). 3) The Nelson-Denny Reading Test (Brown, Bennett & Hanna, 1981). 4) A multiple choice pretest assessing students' knowledge of the content in which instruction was to occur. In prior research (Tobias & Everson, 1985) the pretest was found to have an alpha reliability of .75.

Prior to beginning the instructional materials students were randomly assigned to receive one of two introductory passages. One of these, the explanation group consisted of a 74 sentence passage, also presented in numbered sentences one at a time, describing all of the options, how they could be invoked, and requiring at least one use of each option to assure that students knew how they could be invoked. An explanation of the importance of review, based on material used by Garner et al (1984), was then provided. The passage indicated that most ppeople could not retain all the content in a

passage during one reading and that review was useful to assure that previous reading had been mastered. Students then read an extremely difficult paragraph dealing with the diagnosis of myocardial infarction and were urged to review that paragraph to assure that they had mastered it. Those who did not voluntarily choose to re-read this paragraph were required to do so. Finally, a summary of the advantages of review was presented. The no explanation group read only a 51 sentence description of the options and used each option once; no explanatory material describing the value of review was provided to this group.

Students were also randomly assigned to three presentation modes. 1) An adjunct question group received a question requiring fill-in responses after the preceding screenful of text had been erased. Screenfuls consisted of two to three paragraphs. 2) A required review group was identical to the preceding one except that when responses to the adjunct questions were incorrect students were required to review the prior text and re-answer the adjunct question. This procedure was repeated if the second answer was wrong. If an incorrect answer was given a third time it was evaluated by a research assistant. If the assistant judged the response to be correct, students continued to the next segment. If the answer was judged to be incorrect students had to perform one additional review and, if the succeeding response was still wrong, the right answer was supplied before students continued with the text. The computer program compared students' responses to a pre-stored list of correct answers and their semantic equivalents. The answer set was searched for correct concepts and ignored likely misspellings. Thus, when the required response was the word

multiply, any response containing "mltp" was considered a creditable answer. 3) Reading. This group read the instructional material without questions.

The text was presented on Apple II+ and IIe microcomputers, one sentence at a time. Each sentence was numbered. When students touched the space bar, the preceding sentence was deleted, though its number and the space it occupied was left vacant, and the succeeding sentence displayed. At the bottom of the screen a data line indicated the options available to students at that point.

In the middle of the text material a Worry-Emotionality Scale (Morris, Davis, & Hutchings, 1981) was presented on computer with instructions to complete the instrument in terms of the way students felt while reading the text. After completing the passage and posttest another Worry-Emotionality Scale was administered in which students were asked to describe their feelings while taking the posttest.

Subjects

A total of 130 high school student volunteers served as subjects in this experiment. The sample was composed of 37 males, and 99 females. There were a total of 92 freshmen, 25 sophomores, 16 juniors, 1 senior; the classes of two subjects were not available. Students were paid $7.00 for their participation.

Results

The data were analyzed to determine the effects of instruction, presentation mode, pretest and anxiety, and those interactions which were of theoretical relevance on two data sets: (a) The incidental and relevant posttest. (b) Options use. Table 5.1 presents the

Insert Table 5.1 about here

means and standard deviations for all groups on the pretest, anxiety measures, and the incidental, relevant and total posttests.

The data were analyzed by multivariate multiple regression analysis using the SPSSx (1983) MANOVA program. The results of the regression analysis, displayed in Table 5.2, indicate that pretest exerted a significant multivariate effect on posttest, with significant univariate effects for both relevant and incidental posttest. Mode of responding also had a significant multivariate

Insert Table 5.2 about here

effect, though neither of the univariate effects were significant. Finally, there was a significant multivariate interaction between review instruction and pretest in addition to univariate interactions for these variables on both relevant and incidental posttest. Both interactions were disordinal and are displayed in Figures 5.1 and 5.2. There was also a significant univariate

Insert Figures 5.1 and 5.2 about here

interaction, displayed in Figure 5.3, among explanation, presentation modes and pretest on the relevant posttest.

Insert Figure 5.3 about here

Group means for students' use of the various macroprocessing options and correlations between option data and pretest, posttest, and anxiety within each group, are displayed in Table 5.3.

Insert Table 5.3 about here

For the mandatory review groups the total number of main text sentences re-read consisted of two types: a) Mandatory reviews, i.e., sentences students were required to re-read after giving a wrong answer to an adjunct question and b) voluntary reviews, or sentences re-read at all other times. The data for the forced and voluntary sub-categories of main text reviews are also displayed in Table 5.3. Since the reading group did not receive any adjunct questions, the forced and voluntary categories are meaningless for those subjects. Multiple regression analysis indicated that required reviews contributed significantly to total posttest (F =42.55, p <.001), as well as to incidental (F =29.97, p <.001) and relevant posttest (F =42.74, p <.001). On the other hand, voluntary review was not significantly associated with posttest (all F values =<1) for these groups.

Review was always optional for the adjunct question groups. It was, however, also possible to separate reviews performed by these groups into two categories: Sentences re-read after students were asked whether they wished to correct a wrong answer to an adjunct question, and those reviewed at any other time. Multiple regression analysis indicated that the number of sentences reviewed after incorrect answers to adjunct questions were significantly associated with total posttest (F =6.56, p <.01), as well as with relevant (F =4.87, p <.05) and incidental posttest (F =6.72, p <.01), whereas sentences re-read at all other times were not related to total (F =1.77), relevant (F =2.64) or incidental (F =<1) posttest.

The significance of differences on macroprocessing data was also

evaluated by multivariate multiple regression analysis. The results of that analysis, displayed in Table 5.4, indicate that there

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Insert Table 5.4 about here

---

was a significant multivariate effect attributable to presentation modes, as well as univariate differences on this variable for both the number of main text sentences reviewed and for notes taken. No other multivariate main effects achieved significance, though there were univariate effects attributable to pretest on the number of times notes were taken. None of the multivariate interactions were significant, though there was a significant univariate interaction among presentation mode and pretest for number of main text sentences reviewed. Another univariate interaction was between explanations and pretest scores on the number of notes taken. These interactions are depicted in Figures 5.4 and 5.5.

Insert Figures 5.4 and 5.5 about here

The number of alternate text sentences read were not retained in this study. However, data on the frequency which students used this option, were available. The frequency results differed from the total number of sentences read in that any inspection of alternate text, irrespective of the number of sentences counted as one option use. Evidence suggests that the frequency and number of sentences consulted data were probably quite similar, since the correlation between the number of alternate sentences reviewed, and the frequency of alternate review was .88. Multiple regression analysis of the alternate text frequency data indicated that there were no significant main effects or interactions involving those findings.

Discussion

The results dealing with outcomes and use of macroprocesses will be discussed first, followed by a general consideration of the implications of these data for ATI research, and for the improvement of students' comprehension.

Posttest Results

Multivariate differences among the three presentation modes were found, though the variability of the incidental and relevant posttest data probably prevented the univariate analyses from attaining significance. On the relevant posttest, the reading groups received lower scores than any others, see Table 5.1. On the other hand, for incidental items the group reading the text with explanation of the value of review obtained the highest scores, followed by those reading the text without such explanation. These results can be explained by the tendency of questions to focus students' attention to various parts of the text (Anderson & Biddle, 1975; Rickards, 1979). The groups questioned about the text probably paid more attention to content covered by questions, leading to their better performance on that section of the posttest. Since students in the reading group did not receive any questions, they probably devoted more attention than the other groups to the parts of the text not covered by adjunct questions, i.e., material on the incidental posttest.

The interactions between explanation and pretest, Figures 5.1 and 5.2, indicate that, as expected, receiving an explanation of the value of review helped the comprehension of students with limited prior knowledge of the content. Apparently, even the brief explanation about the value of review provided in this study helped

students with limited prior experience with this material to learn more effectively. Explanation interfered with the learning of knowledgeable students who were somewhat above the mean on pretest. Presumably, knowledgeable students had effective review strategies relevant to this content and found the explanations provided in this study less useful than their own strategies. This interaction is similar to others described by Snow and Lohman (1984), who suggested that instruction in cognitive processes often facilitates the performance of poor learners but can interfere with the learning of capable students whose personal strategies may be more effective than those taught.

The interaction among explanation and presentation modes, Figure 5.3, on the relevant posttest further clarifies these findings. On the relevant posttest explanation appeared to have been of value to students who read the material without adjunct questions irrespective of pretest scores. Perhaps, these students gained from explanations because they received less instructional support than all other groups and were able to focus more intently on the explanation. Both the intercept and slope of the regression functions for the two adjunct question groups in Figure 5.3 were very similar, indicating no effect as a result of explanation, or interaction between explanation and pretest for students for whom review was optional. In the mandatory review groups, explanation was beneficial for students above the mean on pretest and impaired the performance of those below the mean. Possibly, the combination of explanations and forced review may have diverted the attention of these less knowledgeable students from the text by overloading them with too many procedural concerns, leading to the negative slope of this

function.

The finding that posttest scores for the reading groups were substantially lower than for the required and optional review groups, irrespective of explanations, indicates that both adjunct questions and requiring students to review had strong facilitative effects. Since the groups responding to questions generally out-performed students in the reading with explanations group, explanations seem not to be as effective as adjunct questions or requiring review.

Macroprocessing Results

The interaction between explanation and pretest on number of times notes were taken, Figure 5.5, indicates that students who received explanations about the effectiveness of review took more notes than others. The differences between the explanation and no-explanation groups were slightly larger at lower than at upper pretest levels, indicating that the explanations induced students with limited prior knowledge of the subject matter to take somewhat more notes than they would have otherwise. In general, however, pretest was positively correlated with note frequency.

The significant multivariate differences among the three presentation modes on use of macroprocessing options was largely attributable to large differences in the number of main text sentences reviewed. Table 5.3 indicates that the mandatory review group re-read more sentences than the adjunct question group, and in turn that this group reviewed more than the group merely reading the text. Group differences in number of sentences reviewed were attributable to requiring re-reading after incorrect answers to adjunct questions. Both required review groups re-read 58% more sentences after wrong answers to adjunct questions than the adjunct

question groups who were prompted, but not required to review after answering an adjunct question incorrectly, though voluntary review differences between the adjunct question and required review groups were negligible. The explanation groups reviewed fewer sentences than those without explanation, though this difference was not significant. The prompted and required review results were less variable with respect to their respective means than the voluntary review data for the groups receiving questions, or than the review data for the reading group. These results suggest that review may have been used less randomly when students were prompted or required to review, than when they were left to their own devices.

The interaction between pretest and mode of responding, displayed in Figure 5.4, indicates that the number of sentences reviewed increased slightly for groups reading the text, whereas it declined dramatically for both the optional and mandatory review groups. This decline was probably caused by the fact that more knowledgeable students committed fewer errors and, therefore were forced or prompted to review less frequently than those with less familiarity with this content.

Review differences are clarified by the findings of this and the two preceding studies (Tobias, 1985a; Tobias & Sacks, 1985). In all three investigations compulsory reviews, i.e., when students were forced to re-read after making an incorrect answer to adjunct questions, were significantly associated with posttest scores, whereas voluntary reviews were not. In the adjunct question groups, those sentences re-read after students made an incorrect answer-though they were not forced to review-were significantly associated with posttest scores, whereas all other reviews were not.

These findings, and the variability of the review data mentioned above, continue to suggest that students do not use review very strategically. In both optional and required review groups, student's re-reading after being informed that their answers to adjunct questions were incorrect contributed significantly to posttest scores, whereas all other reviews did not. Apparently, external information regarding inadequate comprehension is required in order to use review effectively.

General Discussion

The interaction between explanation and pretest confirms the ATI hypothesis of an inverse relationship between prior experience and instructional support (Tobias, 1982). Students with less familiarity with this content profited most from the explanations, whereas the learning of more knowledgeable students was slightly impaired by such instruction. The findings confirm the hypothesis guiding this study that instruction in the use of macroprocesses is required so that less knowledgeable students can use such processes effectively. Further ATI research may be most profitably conducted in training environments in which students with limited prior knowledge can be expected to profit most from instructional support, compared to their more knowledgeable counterparts. In contrast to prior research (Tobias & Sacks, 1983, 1985) there were no effects of anxiety on review.

The results of this study indicate that providing even a brief explanation of the value of review improved the learning of students with limited prior knowledge of the subject matter. The findings regarding both explanation and review suggest that monitoring students while reading meaningful text in order to prompt or require

review improves performance. The fact that such improvement could occur in a relatively brief experimental session, lasting approximately an hour and a half, suggests that more intensive training may lead to substantial increments in achievement. Furthermore, it should be noted that explanation of the value of review was effective for less knowledgeable students, despite continued evidence regarding relatively unstrategic use of review by such students. These results confirm the findings of other investigators (Paris, Cross & Lipson, 1985; Palincsar & Brown, 1984) that the reading of less knowledgeable students can be made more strategic by instruction.

Requiring review when answers to adjunct questions were incorrect increased the number of sentences reviewed compared to prompting such reviews, and in turn, such prompted re-reading led to greater use of reviews than reading the text without questions. Those receiving an explanation reviewed fewer sentences overall than those without explanation and re-read somewhat more sentences voluntarily- though neither of these difference was significant. The variability of review data was also lower for the groups with an explanation than for the others. These trends also confirm the interpretation suggested above that reviews by groups with an explanation were less random and more strategic than those of students in the other groups, leading to improved comprehension for less knowledgeable students.

The results of the present research project suggest that a training program in which students are taught how to use review strategically may lead to improved comprehension. The data indicate that external monitoring and intervention is needed in order to

increase students' use of review. Trends in the data suggest that explanations tend to make students' review more strategic than they usually are. Therefore, a promising next step to this project would be to extend the research to the development of a review training program. In such a program students may be provided maximal external support for review early in the instructional sequence, with gradual shifting of responsibility for monitoring of comprehension and initiating review from the computer to students. The results of the present research suggest that such a program appears likely to improve students' comprehension, especially for students with limited prior knowledge of the subject matter. The research of Paris, Cross, and Lipson (1985) and of Palincsar and Brown, (1985) have indicated that metacognitive training in general can improve students' learning from reading. The results of this project indicate that training in strategic use of review may well be equally effective.

Legend of Figures

Figure 5.1. Interaction between explanation and pretest on relevant posttest.

Figure 5.2. Interaction between explanation and pretest on incidental posttest.

Figure 5.3. Interaction among pretest, explanation and presentation modes on relevant posttest.

Figure 5.4. Interaction between presentation modes and pretest on number of main sentences reviewed.

Figure 5.5. Interaction between explanations and pretest no notes taken.

Table 5.1 Means and Standard Deviations for Selected Dependent and Independent Variables by group.

		No Explanation			Explanation		
		Reading	Adjunct Question	Forced Review	Reading	Adjunct Question	Forced Review
		N = 25	N = 25	N = 22	N = 23	N = 21	N= 20
Variables							
Pretest	M	16.24	17.36	16.36	20.00	19.14	17.90
	SD	8.31	6.26	5.62	14.54	5.31	6.24
Incidental Posttest	M	8.34	8.06	6.84	9.35	9.64	9.00
	SD	4.20	3.96	4.10	3.82	4.39	4.73
Relevant Posttest	M	8.31	12.35	11.67	8.96	15.10	13.92
	SD	5.08	6.47	4.77	5.27	6.15	6.58
Total Posttest	M	16.65	20.41	18.51	18.31	24.75	22.92
	SD	9.00	9.76	8.44	8.79	9.73	10.91
Worry Pretest	M	9.28	8.44	9.00	11.48	8.28	7.95
	SD	4.12	4.12	3.75	9.42	3.39	5.40
Worry Program	M	10.00	8.84	9.68	9.39	8.52	9.70
	SD	4.37	3.26	4.82	3.07	2.79	4.29
Worry Posttest	M	13.32	8.92	10.09	13.09	8.05	9.95
	SD	4.88	5.69	4.52	5.02	4.00	4.59
Nelson Denny *							
Vocabulary	M	31.36	30.56	28.82	38.78	34.90	31.90
	SD	15.82	8.85	11.38	25.58	14.30	16.27
Comprehension	M	53.52	29.28	28.82	36.43	34.86	32.70
	SD	93.71	10.92	12.43	17.92	10.93	15.34
Total	M	88.92	59.84	62.18	75.22	69.28	64.60
	SD	109.39	18.56	30.31	42.37	23.76	29.33

* Raw Score

Table 5.2 Multivariate and Univariate Multiple Regression Analyses of Posttest Results.

		Univariate Posttest Results	
Independent Variables	Wilks[2]	Incidental	Relevant
Explanation (E)	.24	<1	<1
Presentation Mode (M)	5.40**	1.51	1.77
Pretest (Pre)	6.51**	12.52**	9.60**
Worry (WP)[1]	1.80	2.34	3.57
E X M	.22	<1	<1
E X Pre	5.71**	11.11**	8.17**
M X Pre	.76	<1	<1
M X WP	.14	<1	<1
E X M X Pre	1.78	1.93	3.63*

[1] Worry scale administered after posttest.

[2] Expressed in terms of approximate F scores.

** p. <.01

* p. <.05

Table 5.3 Means and Standard Deviations and Correlations with Posttest, Pretest and Worry for Option Use Data.

		No Explanation			Explanation		
		Reading	Adjunct Question	Required Review	Reading	Adjunct Question	Required Review
Main Text[1]							
Reviews	M	12.00	79.20	133.41	6.74	75.90	120.20
	SD	17.60	60.49	65.75	9.96	35.39	74.73
r Posttest		.18	-.46*	-.69**	-.03	-.14	-.72**
r Pretest		.41*	-.21	-.62**	.02	.06	-.27
r Worry		-.16	.00	.50*	.02	.24	.18
Reviews After Question	M	--	72.92	128.14	--	66.19	111.55
	SD	--	60.99	66.63	--	38.90	77.86
r Posttest		--	-.47*	-.70**	--	-.22	-.76**
r Pretest		--	-.19	-.60**	--	-.02	-.28
r Worry 2		--	.01	.46*	--	.31	.19
Voluntary Reviews	M	--	6.16	5.91	--	9.33	15.4
	SD	--	7.18	10.59	--	10.50	30.45
r Posttest		--	.09	-.03	--	.33	-.31
r Pretest		--	-.16	-.20	--	.27	-.11
r Worry 2		--	-.03	.24	--	-.34	.06
Alternate[1] Text Reviews	M	9.76	2.52	2.77	4.39	5.81	8.35
	SD	18.56	3.29	9.63	9.38	8.89	13.90
r Posttest		.36	.40	.03	.16	.36	-.31
r Pretest		.22	.26	.40	-.15	.30	.01
r Worry		-.12	.03	-.09	-.13	-.08	.10
Inspection of[1] Alternate Text	M	2.48	4.96	3.86	7.00	5.86	7.20
	SD	5.28	8.92	9.26	11.29	11.15	11.71
r Posttest		.16	.46*	.14	.32	.17	.01
r Pretest		.32	.41*	.38	.05	-.16	.17
r Worry		.36	-.18	-.27	.01	-.39	.12
Notes	M	9.24	4.32	2.54	8.09	8.48	6.90
	SD	9.47	6.24	5.71	8.62	10.67	8.40
r Posttest		.37	.27	.03	.35	.02	.43*
r Pretest		.37	-.05	.50*	-.13	.21	.28
r Worry		.08	.11	-.14	.24	-.23	-.06
Review Notes	M	.72	.64	.46	.96	.48	1.15
	SD	1.34	1.50	1.60	1.96	.93	2.32
r Posttest		.31	-.11	.09	.15	-.24	.40
r Pretest		.30	-.51*	.37	-.17	.07	.02
r Worry		-.43*	.43*	-.20	.30	.05	-.14
Options Menu	M	.92	1.36	.68	.61	.62	.90
	SD	1.50	1.82	1.13	.84	1.40	1.48
r Posttest		.21	-.36	.08	-.12	-.10	-.31
r Pretest		.31	-.22	-.06	.03	-.11	-.26
r Worry		.23	.29	-.12	.17	.12	-.03

[1]Number of Sentences
[2]Worry scale administered during program
** p. <.01
* p. <.05

Table 5.4 Multivariate and Univariate Multiple Regression Analyses of Option Utilization Data.

		Univariate Results				
Independent Variables	Wilks[2]	Main[3] Text Reviews	Alternate[3] Text Reviews	Notes	Review of Notes	Options Menu
Explanation (E)	.90	<1	2.75	<1	<1	<1
Presentation Mode (M)	7.38**	31.90**	2.95	4.05*	<1	1.54
Pretest (Pre)	1.46	<1	1.06	5.02*	1.28	3.11
Worry (W)[1]	1.10	<1	<1	1.49	<1	1.57
E X M	1.24	<1	2.32	1.43	<1	1.21
E X Pre	1.26	<1	1.49	4.64*	2.23	1.85
M X Pre	1.82	4.47**	<1	1.37	2.86	2.07
M X W	1.29	1.25	<1	<1	<1	1.26
E X M X Pre	.94	1.14	<1	1.92	2.11	<1

1 Worry scale administered during reading.

2 Expressed in terms of approximate F scores.

3 Number of Sentences.

** p. <.01
* p. <.05

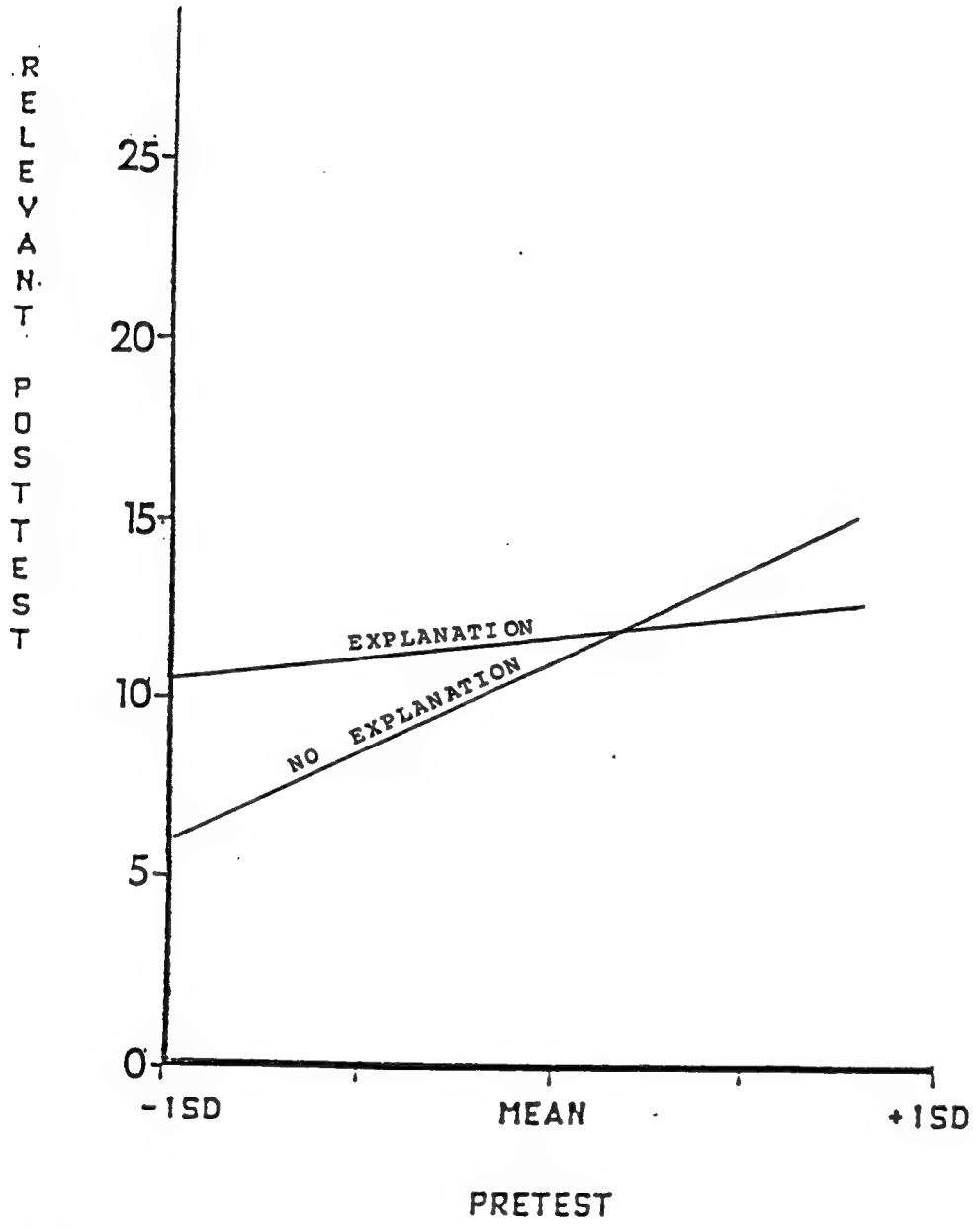
RELEVANT POSTTEST
25
20
15
10
5
0
EXPLANATION
NO EXPLANATION
-1SD
MEAN
+1SD
PRETEST

FIGURE 5.1

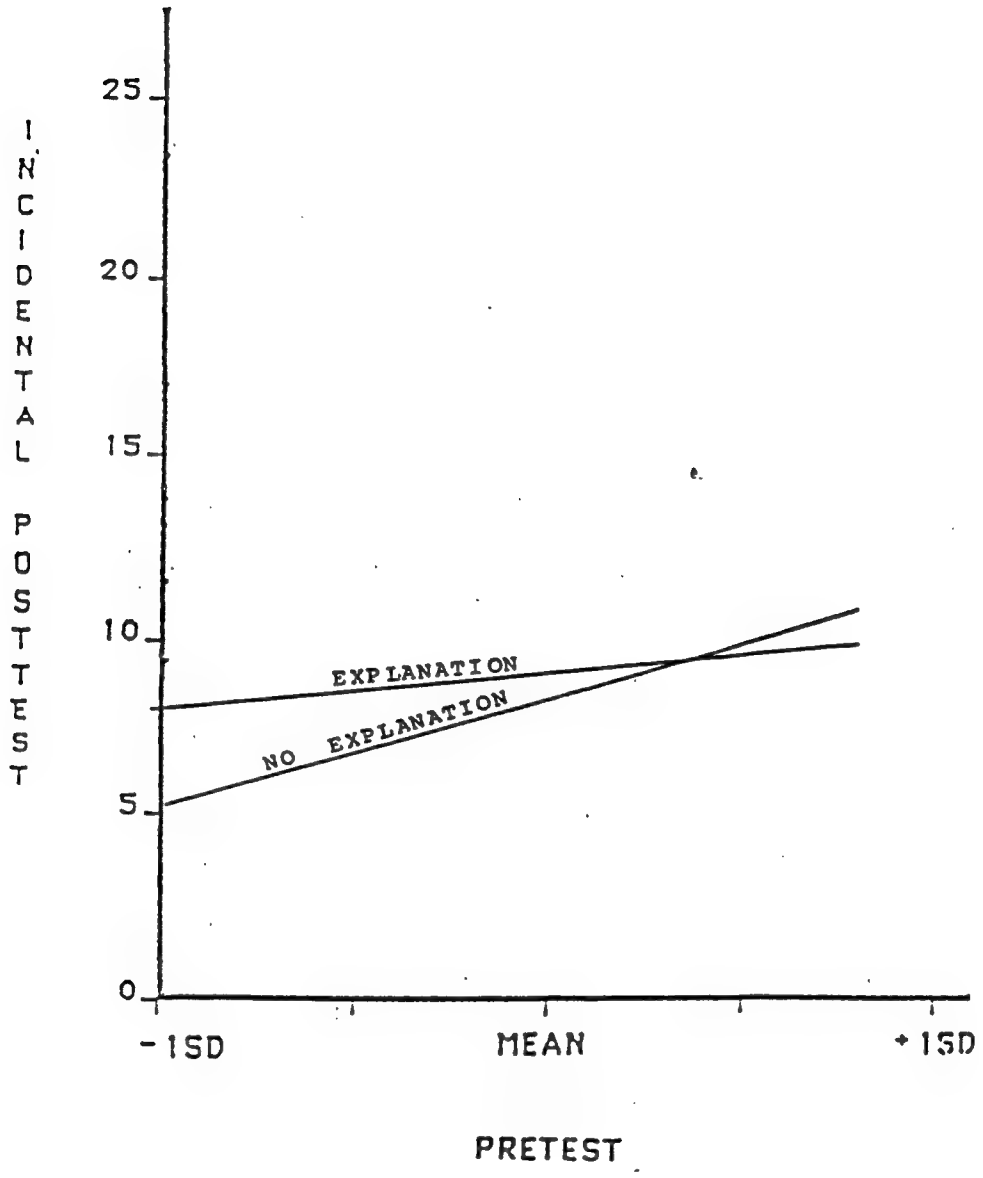
INCIDENTAL POSTTEST
25
20
15
10
5
0
EXPLANATION
NO EXPLANATION
-1SD
MEAN
+1SD
PRETEST

FIGURE **5.2**

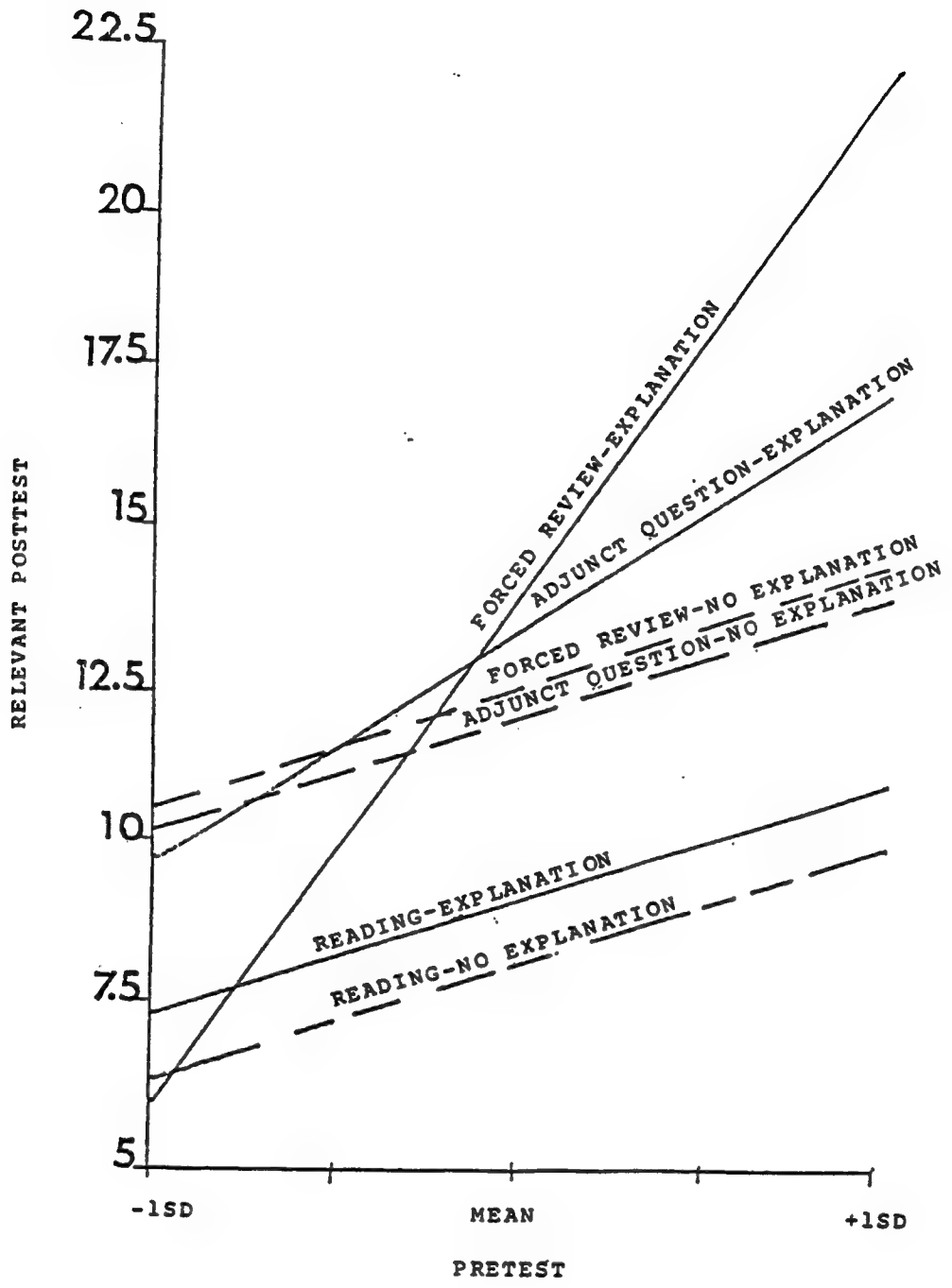
22.5
20
17.5
15
12.5
10
7.5
5
RELEVANT POSTTEST
FORCED REVIEW-EXPLANATION
ADJUNCT QUESTION-EXPLANATION
FORCED REVIEW-NO EXPLANATION
ADJUNCT QUESTION-NO EXPLANATION
READING-EXPLANATION
READING-NO EXPLANATION
-1SD
MEAN
+1SD
PRETEST

FIGURE 5.3

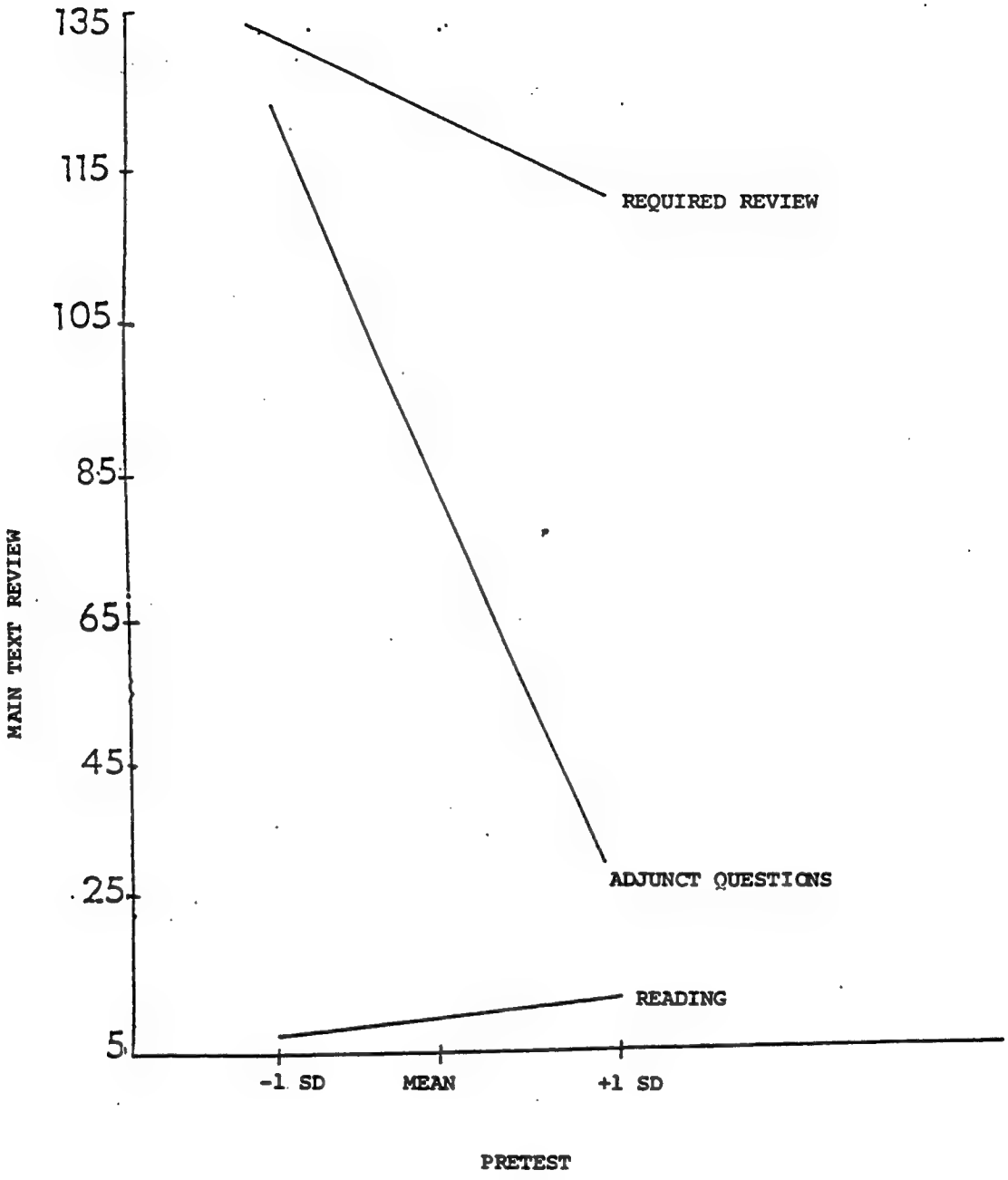
135
115
105
85
65
45
25
5
MAIN TEXT REVIEW
REQUIRED REVIEW
ADJUNCT QUESTIONS
READING
-1 SD
MEAN
+1 SD
PRETEST

FIGURE 5.4

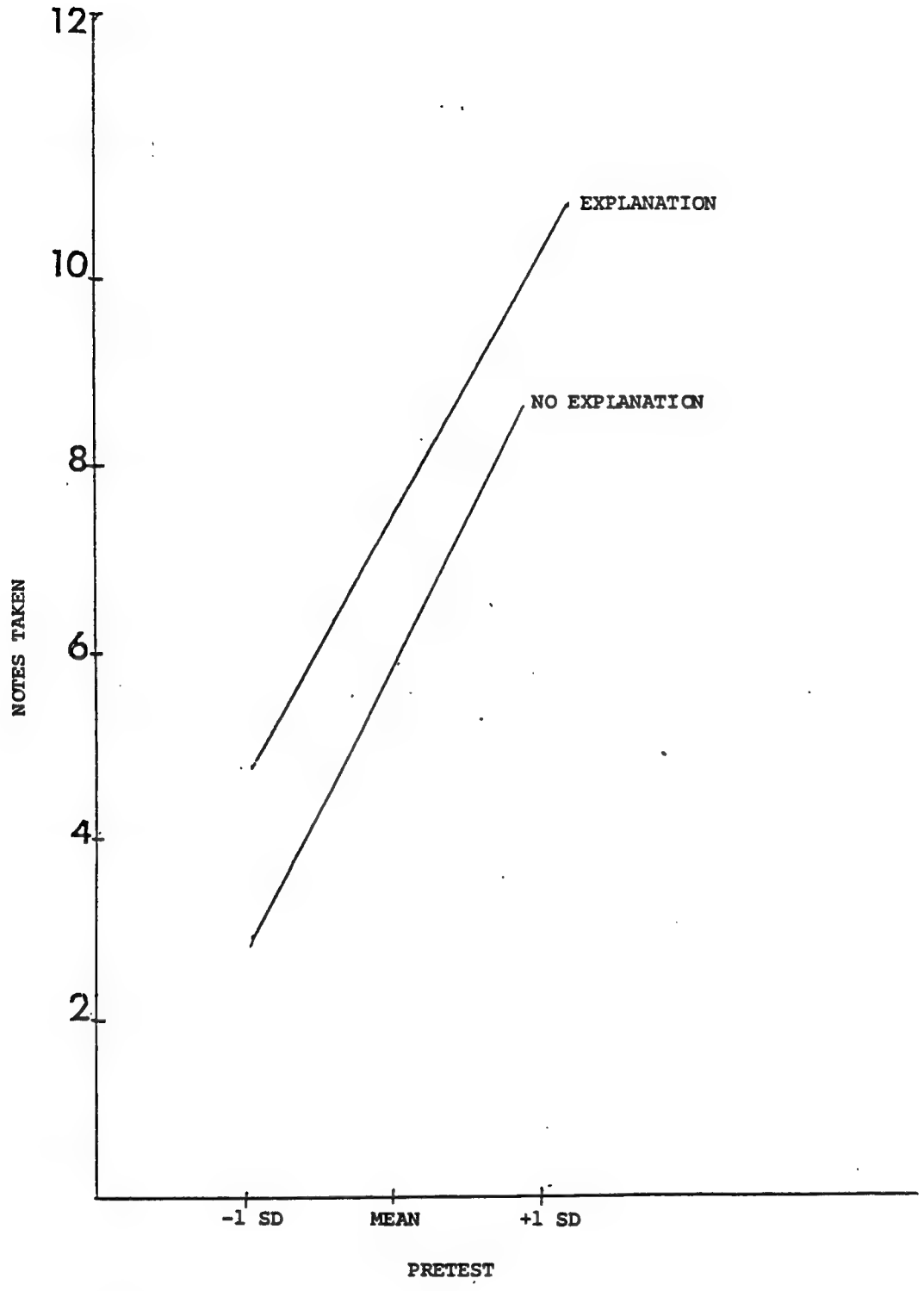
12
10
8
6
4
2
NOTES TAKEN
EXPLANATION
NO EXPLANATION
-1 SD
MEAN
+1 SD
PRETEST

FIGURE 5.5

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